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Safety Evaluation Report

related to the operation of Diablo Canyon Nuclear Power Plant, Units 1 and 2

Docket Nos. 50-275 and 50-323

Pacific Gas and Electric Company

Supplement No. 18

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

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ABSTRACT

Supplement 18 to the Safety Evaluation Report for Pacific Gas and Electric Company's application for licenses to operate Diablo Canyon Nuclear Power Plants, Units 1 and 2 (Docket Nos. 50-275 and 50-323), has been prepared by the Office of Nuclear Reactor Regulation of the U.S. Nuclear Regulatory Commission. This supplement reports on the verification effort for Diablo Canyon Unit 1 that was performed between November 1981 and the present in response to Commission Order CLI-81-30 and an NRC letter to the licensee.

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ABBREVIATIONS

ACI	American Concrete Institute
ACRS	Advisory Committee on Reactor Safeguards
AFW	auxiliary feedwater
AFWS	auxiliary feedwater system
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
ANS	American Nuclear Society
ANSI	American National Standards Institute
ASLAB	Atomic Safety and Licensing Appeal Board
ASLB	Atomic Safety Licensing Board
ASME	American Society of Mechanical Engineers
ASW	auxiliary salt water
BIR	Blume Internal Review
BNL	Brookhaven National Laboratory
CAP	Corrective Action Program
CCW	component cooling water
CCWS	component cooling water system
CQA	construction quality assurance
CRVPS	control room ventilation and pressurization system
DCNPP	Diablo Canyon Nuclear Power Plant
DCP	Diablo Canyon Project
DDE	double design earthquake
DDOF	dynamic degree(s) of freedom
DE	design earthquake
DFOTS	diesel fuel oil transfer system
EDS	EDS Nuclear, Inc.
EOI	Error or Open Item
FOT	fuel oil transfer
FSAR	Final Safety Analysis Report
GDC	General Design Criteri(on) (a)
GFA	Guy F. Atkinson Co.
HLA	Harding Lawson Associates
HVAC	heating, ventilation, and air conditioning
IDVP	Independent Design Verification Program
IE	Office of Inspection and Enforcement (NRC)
IEEE	Institute of Electrical and Electronics Engineers
ITP	Internal Technical Program
ITR	Interim Technical Report

LCV	level control valve
LOCA	loss-of-coolant accident
MAFW	motor-driven auxiliary feedwater
MCB	main control board
MSS	main steam system
NRC	U.S. Nuclear Regulatory Commission
NSC	Nuclear Service Corporation
OBE	operating basis earthquake
OIR	Open Item Report
OWST	outdoor water storage tank
PG&E	Pacific Gas and Electric Company
QA	quality assurance
RFI	request(s) for information
RFR	R. F. Reedy, Inc.
RLCA	Robert L. Cloud and Associates
RRA	Radiation Research Associates
SEAOC	Structural Engineers Association of California
SER	Safety Evaluation Report
SIF	stress intensification factor
SIFPR	Supplementary Information for Fire Protection Review
SRSS	square root of the sum of the squares
SSE	safe shutdown earthquake
SSI	soil-structure interaction
SWEC	Stone & Webster Engineering Corporation
TAFW	turbine-driven auxiliary feedwater
TES	Teledyne Engineering Services
TMI	Three Mile Island
UL	Underwriters Laboratory
W	Westinghouse
W&B	Wismer & Becker
ZPA	zero period acceleration

1 INTRODUCTION

The staff of the U.S. Nuclear Regulatory Commission (NRC) issued on October 16, 1974, its Safety Evaluation Report (SER) in matters of the application of the Pacific Gas and Electric Company (PG&E) to operate Diablo Canyon Nuclear Power Plant, Units 1 and 2. The SER has since been supplemented by Supplement Nos. 1 through 17. This SER supplement is No. 18 and presents the staff's safety evaluation on matters related to a verification effort that was the result of Commission Order CLI-81-30 and an NRC letter to PG&E of November 19, 1981. The verification effort relates only to Unit 1 of the Diablo Canyon Nuclear Power Plant; therefore, this supplement applies only to Unit 1 unless otherwise stated.

This supplement is based on information available to the staff as of June 30, 1983. Certain verification efforts have not been completed. The staff will prepare its safety evaluation on these matters after receiving and reviewing the appropriate information.

The verification effort covers a wide range of subjects that cannot be presented appropriately in the normal format of an SER and its supplements. Therefore, the safety evaluation of the verification effort is reported in Appendix C to this SER Supplement.

Appendix A to an SER Supplement is normally used for an update of the chronology for all Diablo Canyon Nuclear Power Plant related matters. The latest chronology was included in SER Supplement 16 dated August 1983. Therefore, Appendix A has been omitted from this supplement. However, a complete chronology for the Diablo Canyon verification effort has been included in Appendix C.

Appendix B to an SER Supplement is normally for the bibliography to that supplement. In this supplement the bibliography has been included in Appendix C.

Appendix D to this SER Supplement includes the list of contributors and consultants.

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1 BACKGROUND AND GENERAL DISCUSSION

1.1 Background

On September 22, 1981, the NRC issued Facility Operating License No. DPR-76 to PG&E as the licensee for Diablo Canyon Nuclear Power Plant (DCNPP) Unit 1, authorizing fuel loading and low-power testing up to 5% of rated power. On September 28, 1981, PG&E notified the NRC that they had identified an error, which has become known as the mirror image problem or diagram error. An arrangement drawing for DCNPP Unit 2 (which is a mirror image in design of Unit 1) had been used in the seismic analysis of equipment, piping, and supports in the containment annulus structure of Unit 1. At that time fuel loading operations had not commenced and PG&E committed to postpone fuel loading until the adequacy of the seismic analysis and design of Unit 1 was satisfactorily resolved. On the basis of the results of a subsequent inspection performed by NRC Region V and of additional information supplied by PG&E, the NRC staff identified serious weaknesses in the implementation of the PG&E design quality assurance (QA) program, in particular with regard to seismic, service-related contractors. As a result of these findings and concerns the NRC, on November 19, 1981, took the following two actions regarding DCNPP Unit 1.

First, the Commission issued Memorandum and Order CLI-81-30, which suspended Operating License No. DPR-76 and required PG&E to institute an Independent Design Verification Program (IDVP) for seismic, service-related contract activities performed before June 1978. This design verification effort, which has become known as Phase I of the IDVP, must be completed before reinstatement of the low-power license. Second, the NRC staff issued a letter that required further IDVP efforts that must be completed before an NRC decision regarding operation of Diablo Canyon Unit 1 at a power level above 5% of rated power (i.e., full-power license considerations). The IDVP efforts associated with the NRC letter have become known as Phase II of the IDVP and encompass (1) all nonseismic, service-related contract activities performed before June 1978, (2) PG&E internal design activities, and (3) all service-related contract activities performed after January 1978. (Note: throughout this supplement, these two documents are referred to as the Order and the NRC letter.) The program for Phase I and Phase II specifically requires

(1) qualifications of companies proposed to conduct the IDVP

(2) a program plan for the IDVP

(3) biweekly status reports on all efforts of the IDVP

(4) information and results of the program, a report that fully assesses the basic cause and significance of all design errors, PG&E's conclusions on the effectiveness of the program, and a schedule for completing any modifications for DCNPP Unit 1

In addition, the Commission's Order states that before authorizing fuel loading the NRC shall be satisfied with the results of IDVP Phase I and the necessary plant modifications. The NRC may also require completion of additional requirements from Phase II before fuel loading, based on staff's review. Furthermore, the Commission Order and the NRC letter stipulate that the Governor of California and the Joint Intervenors (both of which are parties to the pending Diablo Canyon licensing proceeding) shall have an opportunity to comment on the program plans and specifically on the qualifications of the companies to conduct the IDVP.

1.2 NRC Review and Evaluation

The NRC review and evaluation of the Diablo Canyon design verification program has been an ongoing effort since the Commission Order and NRC letter were issued. In accordance with the Order and the NRC letter, the program plans for Phase I and Phase II were reviewed and evaluated. The organizations proposed to conduct the efforts also were reviewed and evaluated with respect to their financial independence and professional qualifications. The detailed results of those efforts were presented in SECY-82-89 (USNRC, March 1, 1982) and SECY-82-414 (USNRC, October 13, 1982) for Phase I and Phase II, respectively. These documents were the bases for the Commmission's approval of the plans for the IDVP with modifications as recommended by the staff.

The Diablo Canyon design verification program efforts, the methodology and procedures applied to the program, and the criteria for determining the adequacy of the design are described in detail in the Teledyne Engineering Services program plans for Phase I and Phase II, the PG&E program plans for their internal technical program, the Teledyne final report on the IDVP, and the PG&E final reports for Phase I and Phase II of the IDVP. A summary description of the major aspects and milestones of the effort is given below.

The Diablo Canyon Unit 1 verification effort consists of two major programs: (1) the IDVP, Phase I and Phase II, which has been performed by a number of independent organizations under the overall management of Teledyne Engineering Services, and (2) the Diablo Canyon Project (DCP) Internal Technical Program (ITP), which was formulated by PG&E in early 1982 to provide the necessary information to the IDVP and take appropriate actions to address and resolve issues identified by the IDVP, including reanalysis, redesign, and physical modifications for the plant, as necessary.* Another purpose of the ITP is to ensure the overall adequacy of the analysis, design, and construction of the plant, which is the responsibility of PG&E.

In early 1982 the ITP was expanded from a sample-basis approach to a comprehensive verification of the seismic design aspects of all safety-related structures, systems, and components. The program was instituted to better perform the verification and to provide a consistent review and approval process. This aspect of the program is frequently referred to as the Corrective Action Program (CAP). It is a major expansion of the program beyond the scope that originally had been envisioned by the NRC and accounts for most of the engineering design and analysis efforts and resultant plant modifications that have been performed since mid 1982. This effort also is reviewed and verified by the IDVP because it was initiated partially as a result of some

*Throughout this report a reference to the design verification program is meant to include the IDVP and the ITP; a reference to the independent design verification program or effort pertains only to the IDVP.

early IDVP findings and it encompasses the design aspect that is within the purview of the IDVP.

This vastly expanded effort required substantial additional technical resources. Consequently PG&E contracted with Bechtel to establish the DCP, an organizational element within PG&E and composed of PG&E and Bechtel professional and management personnel.

By the fall of 1982, it became evident that the earlier distinction between the pre-1978 and post-1978 effectiveness of design controls was no longer valid; consequently, the timing for completion of Phase I and Phase II activities was no longer needed. At that time PG&E proposed and the Commission approved a three-step licensing process: Step 1, fuel load authorization; Step 2, criticality and low-power authorization; and Step 3, full-power license.

A major change in scope of the design verification program was the expansion to include a selective verification of construction quality assurance (CQA) efforts. The basis for the CQA program, as discussed in detail in Section 2 of this report, was to determine whether quality assurance deficiencies identified with respect to the design did not also exist in the construction of Diablo Canyon Unit 1. The details of the revised verification program are described in detail in SECY-82-414 (USNRC, October 13, 1982).

The objective of the Diablo Canyon design verification program is to demonstrate that the plant has been properly designed to withstand the effects of postulated earthquakes. This goal is to be achieved on two bases: (1) by evaluating the quality assurance programs, including their implementation, of PG&E and their service contractors and (2) by demonstrating that the licensing criteria as set forth in the Diablo Canyon Final Safety Analysis Report (FSAR) and other licensing documents have been met. In the process of design verification, the root causes and the significance of deficiencies in the quality assurance program implementation and in the design are to be identified and evaluated. Therefore, this SER supplement serves two purposes: (1) most importantly, to evaluate the adequacy of the design within the scope of the verification program with respect to the safety of Diablo Canyon Unit 1 and (2) to evaluate the adequacy of the IDVP to achieve the first objective.

The IDVP as directed by the Commission Order and the NRC letter consists of two distinct elements. One is the technical evaluation of the quality assurance and design aspects of Diablo Canyon Unit 1; the other is distinct programmatic guidelines and requirements for the conduct of this program, which include NRC approval of the program plan for Phase I and Phase II and the requirement that the program be performed in an independent manner. The staff evaluation of the programmatic aspects are presented below; the staff evaluation of the technical aspects are presented in Section 2 with respect to quality assurance, in Section 3 for the seismic design verification, and in Section 4 for nonseismic design verification.

The staff evaluation is based on its review of Interim Technical Reports (ITRs) issued by the IDVP (a complete list of ITRs issued as of June 30, 1983, is provided in the Table C.1.1), the PG&E Final Reports for Phase I and Phase II, and the IDVP Final Report. In addition, the staff relied on participation in and observations made at meetings between the IDVP and DCP at which specific technical issues were discussed. Regarding the timeliness of this report, it is based on information provided through June 30, 1983. As stated in the IDVP Final Report and as is reflected in this SER supplement, further information will be provided on activities still in progress. The staff will present its evaluation on these matters in a future supplement to the SER.

Throughout the course of the design verification effort, the staff met often with PG&E and the IDVP organizations to discuss the progress of the effort and ensure that the program met the objectives set forth in the Commission Order and the NRC letter. These meetings were open to the public, and a complete list is provided in Table C.1.2. Notices of these meetings were provided in advance, and the other parties to the Diablo Canyon licensing proceeding were notified directly. To maintain a clear record, to permit documentation of commitments made at the meetings, and to afford other parties not in attendance a review of the discussion, an official verbatim transcript, which was made publicly available, was taken at these meetings. It was the intent of the staff to hear from all parties at those meetings. Representatives of the Joint Intervenors and the Governor of California were provided the opportunity to comment on the matters being discussed and provide their viewpoints. In addition, two meetings were held for the specific purpose of hearing from these parties.

The staff safety evaluation was prepared in support of its recommendation to the Commission regarding the reinstatement of the suspended low-power license and in particular in support of its recommendations regarding authorization for fuel loading of Diablo Canyon Unit 1.

1.3 Independence and Qualification of IDVP Organizations

One of the underlying reasons for the NRC to require a design verification effort for Diablo Canyon Unit 1 by an independent organization was the weakness in the implementation of quality controls by PG&E during the design process. At the onset it was not clear whether the weakness was limited to a particular group within the PG&E organization or if it existed throughout their entire organization as well as in the interactions between PG&E and their service-related contractors. Therefore, the Commission Order and the NRC letter required that the design verification of Diablo Canyon Unit 1 be conducted by an independent organization to ensure an open-minded and critical evaluation of design and the design process. The Commission Order and the NRC letter specified that PG&E provide information which would demonstrate the independence of the companies proposed by PG&E to carry out the IDVP. The criteria the staff used to determine the independence and qualifications of proposed companies are delineated in a letter from Commission Chairman N. Palladino, to Congressmen J. D. Dingell and R. Ottinger dated February 1, 1982, which states:

> The most important factor in NRC's evaluation of the individuals or companies proposed by Pacific Gas & Electric to complete the required design verification program is their competence. This competence must be based on knowledge and experience in the matters under review. These individuals or companies should also be independent. Independence means that the individuals or companies selected must be able to provide an objective, dispassionate technical judgement, provided solely on the basis of technical merit. Independence also means that the design verification program must be conducted by companies or individuals not previously involved with the activities

at Diablo Canyoh that they will now be reviewing. Their integrity must be such that they are regarded as reputable companies or individuals.

The competence of the individuals or companies is the most important factor in the selection of an auditor. Also, the companies or individuals may not have had any direct previous involvement with the activities at Diablo Canyon that they will be reviewing.

The staff evaluated the financial independence and technical qualifications of the proposed companies for Phase I and Phase II of the IDVP. Comments by the Joint Intervenors and the Governor of California on these matters were also considered. The conclusions are presented in SECY-82-89 and SECY-82-414. The following companies were approved:

(1) Teledyne Engineering Services (TES) as the Program Manager for Phase I and Phase II of the IDVP with the following organizations reporting to TES.

(2) Robert L. Cloud and Associates (RLCA) for the seismic design verification of structures, systems, and components in Phase I and Phase II

(3) R. F. Reedy, Inc. (RFR) for the review and verification of quality assurance programs and implementation in Phase I and Phase II

(4) Stone & Webster Engineering Corporation (SWEC) for the verification of nonseismic aspects of the design and analysis of selected safety-related systems and components within the scope of Phase II. SWEC also was assigned the task of performing the construction quality assurance (CQA) audit and verification.

In addition, TES contracted with the following companies to provide expert assistance in specialized areas:

(1) Hansen, Holley, and Biggs, Inc. (civil-structural)
(2) General Dynamics (radiation)
(3) Alexander Kusho, Inc. (electric power)
(4) Foster-Miller Associates (instrumentation and control)
(5) J. W. Wheaton (electric power)

Professors M. J. Holley and J. M. Biggs were retained by TES in response to a concern expressed by the staff concerning adequate qualifications of the IDVP in civil-structural matters. These individuals provided the necessary expertise on a continuous basis.

The financial independence of individuals of all IDVP organizations with respect to the Diablo Canyon Project was documented during the IDVP in accordance with IDVP Procedure DCNPP-IDVP-PP-005, "Potential or Apparent Conflicts of Interest of Individuals," which includes a requirement for completing a "Statement Regarding Potential or Apparent Conflicts of Interest." The procedure was revised in response to the staff requests that it also apply to IDVP supervisory and management personnel and that it include the relationships with the Bechtel organization (which became a member of the Diablo Canyon Project in March 1982).

From November 1981 through January 1983, NRC Region V conducted inspections related to the independence and professional qualifications of individuals employed by TES, including consultants, Robert L. Cloud and Associates and R. F. Reedy, Inc. These inspections included an examination of conflict-of-interest statements and resumés. In addition, confidential interviews were conducted with IDVP individuals with regard to IDVP management directives for identifying and reporting concerns. The inspections and examinations covered more than three quarters of the individuals employed. The staff concludes that all individuals were technically qualified to perform their completed tasks and that there was no management pressure regarding their professional judgment and attitude. Regarding the financial independence and previous involvement of individuals with PG&E or Bechtel, it was determined that a few individuals of the major IDVP organizations had some previous involvement, primarily as employees of Bechtel. Based on the review of records and interviews, the Region V staff concluded that this involvement was minimal for TES and RLCA employees and would not influence their independence. Three individuals of R. F. Reedy, Inc., were found to have more recent or extensive employment with Bechtel. However, based on further interviews and discussions with these employees, information provided by TES, and detailed information provided by these individuals, the staff determined that there was no continuing financial interest and concluded that they were financially independent and technically qualified for their assignments.

To perform the design verification, the IDVP needed prompt and broad access to all information that was to be verified and the necessary backup information. Much of the information contained in documents such as the FSAR and its amendments and most of the correspondence between PG&E and the NRC is publicly available. These documents can be obtained through the NRC Public Document Room. However, to perform the IDVP in the depth required by the Commission Order and the NRC letter more detailed information was required. This information was available only directly from PG&E or their contractors. In addition, clarification and verification of as-built conditions required direct access to the plant. To obtain this information frequent and direct interactions between the various IDVP organizations and PG&E were required. Throughout the conduct of the IDVP these interactions were in the form of telephone calls, requests for information (RFI), and meetings and site visits both with PG&E and their contractors.

Because of the sensitivity regarding the independence of the verification organizations from PG&E, Teledyne Engineering Services (TES) developed IDVP procedure DCNPP-IDVP-PP-007, "Interface Between IDVP Participants, Diablo Canyon Project and Designated Other Parties." The procedure was revised several times. The staff, in a letter from H. R. Denton (NRC) to W. E. Copper (TES) dated September 29, 1982, commented on the procedure and set forth specific requirements that should be met. In summary, the procedure required that any interaction between the IDVP and the Diablo Canyon Project (DCP) be documented in the IDVP and DCP files. For telephone calls at which substantive information or conclusions were transmitted from the IDVP to the DCP summaries were prepared for the IDVP files. Meetings between the IDVP and PG&E at which substantive information or conclusions were presented or discussed were made known to the NRC staff and to the other parties of the Diablo Canyon licensing proceeding and were open for their attendance. NRC staff attended most of these meetings in order to be fully aware of the concerns under consideration and also to monitor the interaction process between the IDVP and the DCP. Representatives of the Governor of the State of California and the Joint Intervenors were also present at many meetings. On the basis of its attendance at these meetings, the staff finds that these meetings were conducted by the IDVP in a manner to ensure that its determinations and conclusions were not influenced improperly by the DCP. On some occasions the DCP presented its differing viewpoints in a manner that could be interpreted as an attempt to influence the IDVP position or the IDVP process for raising and resolving issues of concern. However, the staff observed that the IDVP was not improperly affected in its deliberations and conclusions.

The issue of maintaining independence was raised by J. R. Reynolds, Counsel to the Joint Intervenors, in a letter of June 23, 1983, addressed to H. R. Denton, NRC, with respect to an IDVP/DCP meeting on June 14, 1983, at which the staff was not present. The staff has received background and explanatory information from the IDVP and PG&E regarding that meeting and concludes that possibly the DCP presented its viewpoint in an improper manner; however, the IDVP was not influenced by the approach.

The staff concludes, on the basis of its attendance at IDVP/DCP meetings and its individual interactions with IDVP and DCP personnel, that the IDVP was conducted in a professional and independent manner and that the conclusions reached by the IDVP were not directly or indirectly influenced by differing viewpoints expressed by the DCP.

1.4 IDVP Verification Process

The scope of Phase I and Phase II of the IDVP has been described above. Both phases were to be conducted on a sample basis in accordance with the Commission Order and the NRC letter. A sample of safety-related structures, systems, and components was selected for the independent design verification. As a result of the Phase I review of the initial sample, the IDVP recommended in Interim Technical Report 1 (ITR 1) that additional verification and sampling be conducted. As discussed earlier, PG&E expanded the scope of its Internal Technical Program (ITP) to include the seismic design aspects of all safety-related systems, structures, and components. The effort consequently included the additional verification and sampling recommended by the IDVP; the subsequent IDVP effort consisted of a verification of the expanded PG&E effort and its results.

In Phase II, the initial sample consisted of three systems: auxiliary feedwater system, control room ventilation and pressurization system, and 4160-V electrical distribution system (safety-related portions only). As a result of the IDVP effort five generic concerns were identified and additional verification was performed in these areas as discussed in Section 4. The PG&E effort with respect to Phase II consisted of providing the necessary information, performing appropriate reviews and analyses, and making plant modifications to resolve the concerns identified by the IDVP.

The IDVP design verification of a structure, system or component of the initial sample began with a review and evaluation of drawings, specifications, criteria, analyses, and calculations that had been established and performed by PG&E or their service contractors for the sample system. Similarly, the audit of quality assurance programs began with a review of the quality assurance manuals. If during this review the IDVP raised a question with respect to meeting the verification criteria, an Open Item Report (OIR) was issued which was entered into the Error or Open Item (EOI) file system and was assigned an EOI file number. Different EOI file number series were used for each of the IDVP organizations and their effort as follows:

EOI File Series	IDVP Organization	IDVP Activity
910-1999	RLCA	Phase I
2000-2999	RFR	Phase I
3000-3999	TES	Phase I
5000-5999	TES	Phase II
6000-6999	RLCA	Phase II
7000-7999	RFR	Phase II
8000-8999	SWEC	Phase II
9000-9999	SWEC	CQA

The opening of a new EOI file indicated that the IDVP had raised a concern; however, the validity and significance of that concern had not necessarily been established or understood. The concern was subsequently identified to PG&E, and its resolution was pursued by obtaining additional information, discussions between the IDVP and the DCP, and plant visits as necessary. If the IDVP determined, as a result of further evaluation, that a particular concern was based on a misunderstanding or misinterpretation of the initial information, that EOI was then closed once it was verified that the licensing criteria had been met. If the IDVP determined that the original concern was valid, it was classified as an "error" in accordance with one of the following error class definitions:

Error Class A - Design criteria or operating limits of a safety-related structure, system, or component are exceeded; physical modification or change in operating procedure is required.

Error Class B - Design criteria or operating limits of a safety-related structure, system, or component are exceeded; resolution is possible by means of more realistic calculations or retesting.

Error Class C - Incorrect engineering or installation of a safety-related structure, system, or component occurred; design criteria or operating limits are not exceeded; physical modification is not required.

Error Class D - Safety-related equipment is not affected; physical modification is not required (this classification was not used for any EOI).

Some EOIs were identified as a "deviation," which is not an error but indicates a departure from a standard procedure and is in itself not a mistake in the analysis, design, or construction of a safety-related structure, system, or component.

The above classification of EOIs was used for concerns that were raised with respect to the independent design verification. EOI files that were opened as a result of quality assurance (QA) audits were classified as a "QA finding" (a nonconformance in QA that required evaluation because of its significance or potential impact on quality) or as a "QA observation" (a nonconformance in QA that did not require evaluation because it had no apparent or real impact on quality).

TES in the IDVP Final Report applied the concept of "finding" and "observation" also to the concerns and issues raised as errors. EOI class A errors and class B errors were combined in a category called "finding," which meant that the license application design criteria or operating limits of safety-related structures, systems, or components had been exceeded and physical modifications, changes in operating procedures, more realistic calculations, or retesting were required. EOI class C and class D errors and deviations were combined as "observations." In this case, the significance of the specific item was less than that of a finding, and in the opinion of the IDVP no physical modifications or other significant actions by PG&E were required to satisfy the license application criteria.

The concerns raised during the course of the IDVP (as of June 30, 1983) were documented and issued in 321 individual EOI files. This includes all Phase I and Phase II activities and the construction quality assurance audit. A discussion of these files in presented in Section 5 of this report.

Table C.1.1 Interim Technical Reports (ITRs) and other reports issued by IDVP

Number	Title, IDVP organization, revision, and date
ITR-1:	Additional Verification and Additional Sampling (Phase I) (RLCA). Revision 0, June 10, 1982 Revision 1, October 22, 1982
ITR-2:	Comments on R. F. Reedy, Inc., Quality Assurance Audit Report on Safety Related Activities Performed by Pacific Gas and Electric Prior to June 1978 (TES). Revision 0, June 23, 1982
ITR-3:	Tanks (RLCA). Revision 0, July 16, 1982
ITR-4:	Shake Table Testing (RLCA). Revision 0, July 23, 1982
ITR-5:	Design Chain (RLCA). Revision 0, August 19, 1982
ITR-6:	Auxiliary Building (RLCA). Revision 0, September 10, 1982
ITR-7:	Electrical Raceway Supports (RLCA). Revision 0, September 17, 1982
ITR-8:	Independent Design Verification Program for Verification of Pacific Gas and Electric Company Corrective Action (Phase I) (RLCA). Revision 0, October 7, 1982
ITR-9:	Development of the Service-Related Contractor List for Non-Seismic Design Work Performed for Diablo Canyon Nuclear Power Plant - Unit 1 Prior to June 1, 1978 (RFR). Revision 0, October 18, 1982
ITR-10:	Verification of Design Analysis Hosgri Spectra (RLCA). Revision 0, October 18, 1982
ITR-11:	Pacific Gas and Electric - Westinghouse Interface Review (TES). Revision 0, June 23, 1982
ITR-12:	Piping (RLCA). Revision 0, November 5, 1982
ITR-14:	Verification of the Pressure, Temperature, Humidity, and Submergence Environments Used for Safety-Related Equipment Specifications Outside Containment for Auxiliary Feedwater System and Control Room Ventilation and Pressurization System (SWEC). Revision 0, December 6, 1982 Revision 1, May 9, 1983
ITR-15:	HVAC Duct and Supports Report (RLCA). Revision 0, December 10, 1982
ITR-16:	Soils - Outdoor Water Storage Tanks (RLCA). Revision 0, December 8, 1982

Table C.1.1 (Continued)

Number	Title, IDVP organization, revision, and date
ITR-17:	Piping - Additional Samples (RLCA). Revision 0, December 14, 1982
ITR-18:	Verification of the Fire Protection Provided for Auxiliary Feedwater System, Control Room Ventilation and Pressurization System Safety-Related Portion of the 4160 V Electric System (SWEC). Revision 0, December 13, 1982 Revision 1, May 24, 1983
ITR-19:	Verification of the Post-LOCA Portion of the Radiation Environments Used for Safety-Related Equipment Specification Outside Containment for Auxiliary Feedwater System and Control Room Ventilation and Pressurization System (SWEC). Revision 0, December 16, 1982
ITR-20:	Verification of the Mechanical/Nuclear Design of the Control Room Ventilation and Pressurization System (SWEC). Revision 0, December 16, 1982 Revision 1, April 26, 1983
ITR-21:	Verification of the Effects of High Energy Line Cracks and Moderate Energy Line Breaks for Auxiliary Feedwater System and Control Room Ventilation and Pressurization System (SWEC). Revision 0, December 15, 1982 Revision 1, May 3, 1983
ITR-22:	Verification of the Mechanical/Nuclear Portion of the Auxiliary Feedwater System (SWEC). Revision 0, December 17, 1982 Revision 1, April 26, 1983
ITR-23:	Verification of High Energy Line Break and Internally Generated Missile Review Outside Containment for Auxiliary Feedwater System and Control Room Ventilation and Pressurization System (SWEC). Revision 0, December 20, 1982 Revision 1, May 27, 1983
ITR-24:	Verification of the 4160 V Safety-Related Electrical Distribution System (SWEC). Revision 0, December 21, 1982 Revision 1, May 4, 1983
ITR-25:	Verification of the Auxiliary Feedwater System Electrical Design (SWEC). Revision 0, December 21, 1982 Revision 1, April 29, 1983
ITR-26:	Verification of the Control Room Ventilation and Pressurization System Electrical Design (SWEC). Revision 0, December 21, 1982 Revision 1, May 2, 1983
ITR-27:	Verification of the Instrument and Control Design of the Auxiliary Feedwater System (SWEC).

Table C.1.1 (Continued)

Number	Title, IDVP organization, revision, and date
	Revision 0, December 23, 1982 Revision 1, May 13, 1983
ITR-28:	Verification of the Instrument and Control Design of the Control Room Ventilation and Pressurization System (SWEC). Revision 0, December 23, 1982 Revision 1, May 13, 1983
ITR-29:	Design Chain - Initial Sample (SWEC). Revision 0, January 17, 1983
ITR-30:	Small Bore Piping Report (RLCA). Revision 0, January 12, 1983
ITR-31:	HVAC Components (RLCA). Revision 0, January 14, 1983
ITR-32:	Pumps (RLCA). Revision 0, February 17, 1983 Revision 1, April 1, 1983
ITR-33:	Electrical Equipment Analysis (RLCA). Revision 0, April 28, 1983
ITR-34:	Verification of DCP Effort by Stone & Webster Engineering Corporation (SWEC). Revision 0, February 4, 1983 Revision 1, March 24, 1983
ITR-35:	Independent Design Verification Program Verification Plan for Diablo Canyon Project Activities (RLCA). Revision 0, April 1, 1983
ITR-36:	Final Report on Construction Quality Assurance Evaluation of G. F. Atkinson (SWEC). Revision 0, February 25, 1983 Revision 1, June 20, 1983
ITR-37:	Valves (RLCA). Revision 0, February 23, 1983
ITR-38:	Final Report on Construction Quality Assurance Evaluation of Wismer & Becker (SWEC). Revision 0, March 1, 1983 Revision 1, March 16, 1983 Revision 2, June 20, 1983
ITR-39:	Soils - Intake Structure Bearing Capacity and Lateral Earth Pressure (RLCA). Revision 0, February 25, 1983
ITR-40:	Soils Report - Intake Sliding Resistance (RLCA). Revision 0, March 9, 1983
ITR-41:	Corrective Action Program and Design Office Verification (RFR). Revision 0, April 19, 1983

Table C.1.1 (Continued)

Number	Title, IDVP organization, revision, and date
ITR-42:	R. F. Reedy, Inc., Independent Design Verification Program Phase II Review and Audit of Pacific Gas and Electric Company and Design Consultants for Diablo Canyon Unit 1 (RFR). Revision 0, April 15, 1983
ITR-43:	Heat Exchangers (RLCA). Revision 0, April 14, 1983
ITR-44:	Shake Table Test Mounting Class 1E Electrical Equipment (RLCA). Revision 0, April 15, 1983
ITR-45:	Additional Verification of Redundancy of Equipment and Power Supplies in Shared Safety-Related Systems (SWEC). Revision 0, May 17, 1983.
ITR-46:	Additional Verification of Selection of System Design Pressure and Temperature and Differential Pressure Across Power-Operated Valves (SWEC). Revision 0, June 27, 1983
ITR-47:	Additional Verification of Environmental Consequences of Postulated Pipe Ruptures Outside of Containment (SWEC). Revision 0, June 27, 1983
ITR-48:	To be issued
ITR-49:	Additional Verification of Circuit Separation and Single Failure Review of Safety-Related Electrical Equipment (SWEC). Revision 0, June 23, 1983

NOTE: The following reports were issued by RFR before the establishment of the ITR concept:

1: Review of ANCO Engineers, March 1, 1982.
2: Review of Cygna Energy Services, March 1, 1982.
3: Review of EDS Nuclear Inc., January 20, 1982.
4: Review of Harding Lawson Associates, January 26, 1982.
5: Review of Pacific Gas and Electric Company, March 5, 1982.
6: Review of URS/Blume and Associates, Engineers, March 5, 1982.
7: Review of Wyle Laboratories, March 1, 1982.

Table C.1.2 Meetings on Diablo Canyon Unit 1 verification effort

Date		Participants/attendants/location
(1)	October 9, 1981	NRC, PG&E Bethesda, Md.
(2)	November 3, 1981	NRC, PG&E, Joint Intervenors Bethesda, Md.
(3)	November 9, 1981	NRC Commission meeting Washington, D.C.
(4)	November 16, 1981	NRC Commission meeting Washington, D.C.
*	November 19, 1981	Congressional hearing on Diablo Canyon quality assurance and design errors NRC (Commission), PG&E
(5)	February 3, 1982	NRC, PG&E, TES, RLCA, SWEC Bethesda, Md.
(6)	February 17, 1982	NRC, Joint Intervenors, Gov. of California San Francisco, Calif.
(7)	March 4, 1982	NRC Commission meeting Washington, D.C.
(8)	March 25, 1982	NRC, PG&E, TES, RLCA, RFR, SWEC Bethesda, Md.
(9)	April 1, 1982	NRC, PG&E, TES, RLCA, RFR, SWEC Bethesda, Md.
(10)	June 10, 1982	NRC, TES, PG&E, Bechtel, RLCA, RFR Waltham, Mass.
(11)	July 27, 1982	NRC, BNL, PG&E, TES, RLCA, Bechtel Upton, N.Y.
(12)	August 6, 1982	NRC, PG&E (DCP), Joint Intervenors, Gov. of California, RLCA, SWEC, RFR Bethesda, Md.
(13)	September 1, 1982	NRC, PG&E (DCP), TES, BNL, RLCA, RFR, SWEC, Joint Intervenors, Gov. of California San Francisco, Calif.
(14)	September 9, 1982	NRC, Joint Intervenors, Gov. of California, PG&E (DCP) San Francisco, Calif.
(15)	October 19, 1982	NRC, PG&E (DCP), TES, RLCA, SWEC, Gov. of California Bethesda, Md.

*Meeting held by Congressional subcommittees.

Table C.1.2 (Continued)

Date		Participants/attendants/location
(16)	October 19, 1982	NRC, PG&E (DCP), TES, RLCA, SWEC Bethesda, Md.
(17)	October 20, 1982	NRC Commission meeting Washington, D.C.
(18)	November 10, 1982	NRC Commission meeting, Joint Intervenors, Gov. of California Washington, D.C.
(19)	December 8, 1982	NRC Commission meeting Washington, D.C.
(20)	December 21, 1982	NRC, BNL, PG&E (DCP), TES Westinghouse Upton, N.Y.
(21)	January 13, 1983	NRC, PG&E (DCP), RFR, RLCA, TES, Gov. of California, Joint Intervenors San Francisco, Calif.
(22)	January 28, 1983	NRC, PG&E (DCP), TES, SWEC, Westinghouse (meeting on allegations) Bethesda, Md.
(23)	February 15, 1983	NRC, BNL, PG&E (DCP), TES, RLCA, Gov. of California Bethesda, Md.
*	March 8, 1983	Congressional hearing on Diablo Canyon design NRC verification (Commission), Joint Intervenors, Gov. of California, PG&E Washington, D.C.
(24)	April 19, 1983	NRC, PG&E (DCP), Gov. of California (meeting on component cooling system allegation) San Francisco, Calif.
(25)	May 4, 1983	NRC, PG&E (DCP), Gov. of California, Joint Intervenors, TES, Westinghouse San Francisco, Calif.
(26)	May 20, 1983	NRC, TES, SWEC, Westinghouse, Gov. of California Monroeville, Pa.
(27)	May 21, 1983	NRC, TES, SWEC, Westinghouse, Gov. of California Boston, Mass.
(28)	June 17, 1983	NRC, BNL, PG&E (DCP), RLCA, Joint Intervenors Bethesda, Md.
(29)	July 6, 1983	NRC, BNL, PG&E (DCP), TES Bethesda, Md.

* Meetings held by Congressional subcommittees.

2 QUALITY ASSURANCE

2.1 Introduction

The construction permit for Diablo Canyon Nuclear Power Plant Unit 1 was issued in April 1968. Specific NRC requirements for quality assurance (QA) were not incorporated into 10 CFR 50 until June 1970. These requirements for QA are given in Appendix B to 10 CFR 50, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants." Therefore, significant design efforts were underway for Diablo Canyon Unit 1 before Appendix B was available.

The Commission Order and the NRC letter of November 19, 1981, both required an independent verification of QA procedures, controls, and practices for the design of Diablo Canyon Unit 1. This verification specifically was to include the development, accuracy, transmittal, and use of information regarding safety-related structures, systems, and components within PG&E, within their contractors' organizations, and between PG&E and their contractors.

The QA audit was conducted by R. F. Reedy, Inc. (RFR), reporting to Teledyne Engineering Services (TES) as the IDVP Program Manager. The audit was performed by establishing a checklist of QA requirements from Appendix B and considering NRC requirements for QA in existence at the time when the QA program was reviewed and accepted.

2.2 Design Process Quality Assurance Audits

The QA audits conducted by RFR with respect to the Diablo Canyon Unit 1 design activities compared applicable QA manuals and procedures against the applicable criteria of Appendix B to 10 CFR 50. Following the review of QA manuals and procedures, the implementation of the programs was audited.

In addition to PG&E, the following nine design organizations that performed seismic or nonseismic service-related activities for the design of Diablo Canyon Unit 1 were audited:

(1) ANCO Engineers
(2) Cygna Energy Services
(3) EDS Nuclear, Inc.
(4) Garretson-Elmendorf-Zinov Associates
(5) Harding Lawson Associates
(6) Quadrex
(7) Radiation Research Associates
(8) URS/J. A. Blume & Associates
(9) Wyle Laboratories

The IDVP audit of design QA manuals and procedures determined that of the 10 design organizations, 5 had no QA manual or the QA manual was not applied to the design work performed for PG&E. Two design organizations, including

PG&E, had a QA manual; however, it did not appear to reflect all the pertinent requirements of 10 CFR 50, Appendix B. The other three design organizations had QA manuals that appeared generally acceptable and were used for the work being reviewed.

The results of the audit regarding the implementation of the QA programs also varied. Two design organizations did not implement any QA program, five implemented a QA program that did not appear to meet all the pertinent requirements of 10 CFR 50, Appendix B, and three implemented a QA program that was acceptable.

One purpose of performing the QA reviews and audits was to determine, on the basis of the results of the reviews and audits, if there was a need to expand the IDVP by including additional samples. If the QA program for a design organization was missing or found to be less than entirely acceptable, the scope of the IDVP was to be expanded to verify that the design work performed by that organization was acceptable.

During the early stages of Phase I of the IDVP (before initiation of the Error or Open Item (EOI) file system), the QA reviews and audits resulted in 12 concerns that subsequently were combined and issued as 6 EOIs (EOI 3000 through EOI 3005). They identified the potential need for additional design verification. During Phase II six concerns were issued as EOI 7001 through EOI 7006, which directly addressed required additional design verification. Of the 12 concerns, 2 were combined with EOI 8001, which was classified as an error A/B. Nine concerns were closed by the IDVP on the basis that the IDVP was formulated and conducted so that the program would determine the acceptability of the design regardless of any QA program shortcomings. One concern was issued as an error A/B in EOI 7002.

EOI 7002 resulted from the lack of documented evidence that PG&E had considered the effects of jet impingement on components inside containment. The Diablo Canyon Project will perform a complete reanalysis of the effects of high energy line break jet impingement on safety-related structures, systems, and components inside containment. The IDVP will review a sample of the analysis. The results will be reported by the IDVP in a future ITR.

EOI 8001 addressed concerns about the calculation of pressure and temperature outside containment. Diablo Canyon Project (DCP) analyses resulted in new values for pressure and temperature resulting from postulated pipe breaks in the affected areas which will be incorporated by PG&E into the Unit 1 design. EOI 8001 was closed by the IDVP because of the satisfactory resolution of the concerns expressed.

2.3 Construction Quality Assurance Audits

QA audits of the construction process, although not required by the Commission Order or the NRC letter, were added by PG&E to the independent verification effort to determine whether the construction of Diablo Canyon Unit 1 was in accordance with applicable requirements and whether deficiencies like those found in the design QA would be found in construction QA.

Stone & Webster Engineering Corporation (SWEC) performed the construction quality assurance (CQA) audits for the IDVP. The CQA of two organizations was audited: (1) Guy F. Atkinson Co. (GFA), which performed the erection of the

Unit 1 containment building and (2) Wismer & Becker (W&B), which installed the nuclear steam supply system piping. Experienced auditors, qualified and certified in accordance with American National Standards Institute (ANSI) N45.2.23, reviewed each contractor's QA program and procedures and audited the physical construction of selected components of each constructor's work and as-constructed documentation. Checklists were developed and used for these audits. Potential findings resulting from these audits were reviewed by a Findings Review Committee of the IDVP, composed of five senior SWEC personnel, to determine their significance. The results of this effort are reported in ITR 36, Rev. 1, and ITR 38, Rev. 2, for GFA and W&B, respectively.

As a result of the CQA review and audit of GFA, four concerns were raised and issued by the IDVP as EOIs (9008, 9015, 9016, and 9021). Each of the EOIs was closed when, on the basis of further investigation and evaluation, it was determined they had no real or potential impact on construction quality.

The IDVP review and audit of W&B resulted in a total of 25 concerns which were issued as EOIs. Of these EOIs, 5 were closed when it was found they were invalid, and 19 were classified as "observations" and were closed when, on the basis of further review and evaluation, it was determined they had no real or potential impact on construction quality. One concern, EOI 9026, was classified as a "finding" that required evaluation because of its potential impact on quality. EOI 9026 dealt with the lack of documentation for the liquid penetrant inspection of areas on the reactor coolant piping where lugs had been removed. All lug removal areas were subsequently liquid penetrant inspected and determined to be acceptable. Because the audit verified the performance of all required inspections except this one, it was considered to be a unique occurrence and EOI 9026 was closed.

Staff review of ITR 36, Rev. 0, and ITR 38, Rev. 1, raised questions regarding the rationale for closing out some of the EOIs. Sufficient information had not been provided in the reports to justify adequately the actions taken. The IDVP provided the necessary information in a meeting and in the current revisions to the reports to resolve the staff concerns.

2.4 Quality Assurance for DCP Activities

The staff reviewed the QA program that was applied to the DCP verification effort by PG&E and found it met the pertinent requirements of 10 CFR 50, Appendix B. The program is based on the QA programs for Bechtel and PG&E. The implementation of this QA program was audited, as part of the IDVP, by RFR as it applied to the design corrective action activities and as it applied to the design office.

The IDVP audit of the design corrective action activities noted 24 conditions of incomplete documentation because the audit was performed during the early stages of implementation. A followup audit some months later showed that appropriate actions had been taken to correct the earlier noted conditions to the satisfaction of the audit team. No EOIs were issued.

The audit of the design office included the examination of calculations used by each engineering discipline. Seismic inputs for qualification analyses and discussions with engineers and supervisors were also included. No audit findings were identified which could have either a potential or real impact on the design; thus, no EOIs were issued.

2.5 Quality Assurance for IDVP Activities

The IDVP Program Management Plans for Phase I and Phase II provided the commitment that the activities of the IDVP participants would be conducted in accordance with the applicable requirements of 10 CFR 50, Appendix B, and the QA programs of the IDVP participants referenced in the plan (Teledyne Engineering Services, R. F. Reedy, Inc., Robert L. Cloud and Associates, Inc., and Stone & Webster Engineering Corporation). PG&E audited each of the participants in the program, and Teledyne Engineering Services, as the IDVP Program Manager, also audited the other participants. NRC Region V audits showed that the activities of the IDVP participants were being controlled in accordance with the applicable requirements of 10 CFR 50, Appendix B, by means of appropriate procedures and trained personnel.

2.6 Staff Evaluation

During the course of the IDVP, audits of the establishment and implementation of QA programs of several contractors were conducted relative to Appendix B, some at the specific direction of the staff. The QA audits by the IDVP of the seismic design work by PG&E and its service-related contractors showed that some of the work had been performed with no formal QA program in effect. However, the design verification portion of the IDVP was established to determine acceptability of the Diablo Canyon Unit 1 design in spite of any QA program shortcomings. This is acceptable to the staff.

The QA audits by the IDVP of construction activities, an adjunct effort to the IDVP and proposed by PG&E, indicated adequate implementation of QA controls, consistent with the requirements of 10 CFR 50, Appendix B, so that the IDVP concluded that, in the areas reviewed, the work performed in constructing Diablo Canyon Unit 1 was satisfactory. No physical modifications of Unit 1 were required as a result of the CQA audits. The IDVP found no indication that PG&E failed to adequately control the activities of the construction contractors. The staff concludes that the IDVP conclusions are appropriate and that the IDVP audit scope of this work was acceptable. The CQA audits provide additional assurance that Diablo Canyon Unit 1 construction is acceptable.

The audits of the Diablo Canyon Project activities indicated that corrective action efforts are being performed using the NRC-approved QA program. The program is being effectively implemented.

QA audits of IDVP activities confirmed that the work was being performed in accordance with the applicable requirements of 10 CFR 50, Appendix B. The staff concludes that shortcomings found in and as a result of earlier QA programs for certain design activities are being compensated by verification of the design under the IDVP, that construction was done under acceptable QA controls, and that current corrective actions and the IDVP work itself are being performed in accordance with acceptable QA programs.

3 SEISMIC DESIGN VERIFICATION EFFORT

3.1 Introduction

Following the discovery of the diagram error by PG&E in September 1981, as previously discussed in Section 1, a verification program for the seismic design adequacy of structures, systems, and components was initiated by Pacific Gas and Electric Company (PG&E). URS/John A. Blume & Associates, Engineers (URS/Blume), the original seismic design service contractor, was engaged by PG&E to conduct a review of their Hosgri-related civil-structural analysis and design work. In the meantime, Phase I of the Independent Design Verification Program (IDVP) was established in response to the Commission Order (CLI-81-30), which required performance "of an independent design verification of all safety-related activities performed prior to June 1, 1978 under all seismic-related service contracts utilized in the design process for safety-related structures, systems, and components."

3.1.1 Staff Review and Evaluation Approach

The DCP corrective action effort and the IDVP review and verification described in this report represent an unprecedented effort in terms of design verification. The depth and scope of the DCP and IDVP efforts were tantamount to an original design program while the intensity of the effort was, and continues to be, beyond any previous experience. The typical staff review process is basically a post completion review. This approach, however, could not serve as an adequate basis for staff conclusions from either the standpoint of depth or timeliness. An alternative review approach was therefore used. The staff review was performed to a large extent while the DCP and the IDVP efforts were in progress. The review primarily consisted of performing a series of technical audits of the DCP and the IDVP at various stages of the program, including work in progress, the use of Brookhaven National Laboratory (BNL) as the staff's consultant, direct staff participation in most of the technical interchange meetings between the IDVP and the DCP, and the review of all documents from the DCP and the IDVP as they were issued. Results of these efforts constitute the bases for the staff conclusions reached in this report and in particular in this Section.

A major element in the staff's review and evaluation was the engagement of BNL to independently assess the adequacy of the DCP analyses and to perform studies on selected structures and piping systems. These studies are discussed further in Section 3.6 of this SSER. Some concerns were raised as a result of these studies. The concerns either have been resolved or are being resolved by the DCP and the IDVP. The staff also utilized the assistance of BNL in reviewing all ITRs and the Phase I Final Report issued by the IDVP and by the DCP. The extensive involvement of BNL in the staff review has been incorporated into the staff evaluation and is an integral part of the staff's conclusion as presented in this report.

During the course of the technical audits conducted by the staff and BNL, working and final documents including drawings, detailed calculations, mathematical models and analytical methodology were examined and questioned. This process enabled the staff and BNL to have direct access on a real time basis, to the same material used by the IDVP and DCP engineers. In each of these audits, concerns were raised. Some have been satisfactorily resolved and others are yet to be resolved. However, it is the staff conclusion based on this review that the IDVP sampling procedure and the depth of the verification effort were sufficient to identify deficiencies that might exist in the DCP reverification program. It is also the staff conclusion based on this review that the DCP reverification program was in general well done and should produce reliable results.

3.1.2 URS/Blume Internal Review

PG&E's initial internal review project, commonly referred to as the Blume Internal Review (BIR), was conducted by URS/John A. Blume & Associates, Engineers. The scope of the BIR project included only structures or structural components of the Diablo Canyon Nuclear Power Plant (DCNPP) that were analyzed and/or designed by URS/Blume. The effect of possible response spectrum variations on equipment and piping analyses was not within the scope of this work.

The original objectives of the BIR project were to establish either that the work done met the revised seismic criteria based on the effects of the postulated Hosgri fault or that, with the application of appropriate judgments that were consonant with good engineering practice, the results of the work could be reconciled with the revised criteria and with as-built structures and structural components. However, as the design verification effort expanded and Bechtel Power Corporation was engaged to participate in the PG&E Diablo Canyon Project (DCP), the emphasis of the BIR project was shifted from identifying and evaluating discrepancies to primarily identifying discrepancies and areas where the review was to be completed by the DCP Internal Technical Program (ITP).

The basic review was conducted by URS/Blume personnel who are experienced in seismic analysis but who had little or no involvement in the analysis or design of the specific structure or structural components reviewed. Evaluation of reviewer comments and resolution of the concerns implied by them was performed by URS/Blume personnel who were familiar with the analyses and structures. When some implication of uncertainty in the seismic capacity of a structure or structural component was found, it was identified, described in detail, and brought to the attention of PG&E, along with an evaluation of its impact, and recommended corrective actions.

The results of this review were published in a report entitled "Blume Internal Review (BIR): Independent Internal Review of the Work Done by URS/Blume Engineers on the Diablo Canyon Nuclear Power Plant," dated September 1982. A total of 150 review comments were made. Most were categorized as quality assurance (QA) comments involving classification and augmentation of calculation files, or verification of computer programs. In terms of impact on DCNPP seismic performance, 108 items were determined to have no or insignificant impact, while the impact of the remaining items was to be determined by the ITP and the IDVP.

3.1.3 Independent Design Verification Program

The IDVP managed by Teledyne Engineering Services (TES) was divided into two phases. Whereas the Phase I program considered the response of safety-related structures, systems, and components to the postulated Hosgri 7.5M earthquake and evaluated the results relative to the licensing criteria applicable to that event, the Phase II program considered non-Hosgri seismic conditions with associated loadings and other aspects of safety-related systems and analyses relative to the criteria of the license application. This section will address only the seismic-related activities performed under the Phase I and II programs. The nonseismic aspects of Phase II are addressed in Section 4 of this report.

As stated in Section 1, the objective of Phase I of the IDVP was to conduct an independent and in-depth review of all safety-related activities performed before June 1, 1978, by PG&E and its seismic service-related contractors. On a statistical sampling basis, the review was to determine the adequacy of the DCNPP seismic design for all safety-related structures, systems, and components or identify errors that led to inaccurate results or violations of design criteria. In general, the seismic design aspect of the IDVP effort involved the following tasks.

(1) Establish an initial sample of original work, subject to verification.

(2) Perform a preliminary evaluation of the initial sample.

(3) Report initial concerns resulting from Tasks 1 and 2 to the NRC staff.

(4) Perform additional verification as required on the basis of the initial sample to resolve the specific initial concerns with respect to criteria of the license application and report the resolution.

(5) Based on Tasks 1-4, identify any additional samples that must be considered and additional verification required for evaluation of any generic concerns.

(6) For the subjects identified in Task 5, repeat Tasks 1 through 5.

(7) Identify all aspects that require DCP efforts, including corrective action, and refer them to the DCP.

Task 5 has lost much of its significance during the course of this program because the DCP initiated the ITP, which provided a mechanism for evaluating many of the generic concerns and essentially eliminated the need for additional sampling.

The acceptance criteria used in the IDVP effort are those contained in the Final Safety Analysis Report (FSAR), its amendments, and other pertinent licensing documents. The seismic inputs consisting of ground design response spectra and corresponding acceleration time histories developed for the postulated 7.5M Hosgri earthquake (Hosgri), double design earthquake (DDE), and design earthquake (DE) were used in the IDVP evaluation. The bases for the Hosgri, DDE, and DE were previously approved by the Atomic Safety and Licensing

Board and Atomic Safety and Licensing and Appeal Board and were, therefore, excluded from the IDVP review.

In performing the IDVP, the methodology and acceptance criteria used in the evaluation are given in Section 5.4 of Appendix D to the IDVP report entitled "Diablo Canyon Nuclear Power Plant - Unit 1, Phase I Program Management Plan" submitted by TES, dated March 29, 1982. As of June 1983, a total of 321 Error or Open Item (EOI) files and 49 Interim Technical Reports (ITRs) were issued. These EOIs and ITRs will be identified and addressed in the evaluation of individual buildings, systems, and components given in the following sections.

3.1.4 Independent Studies Performed by Brookhaven National Laboratory

At the staff's request, Brookhaven National Laboratory (BNL) initially performed a vertical seismic analysis for the Unit 1 containment annulus structure and analyzed two piping systems located in the containment annulus area of Unit 1 with PG&E designation numbers 4A-26 and 6-11. The objectives of this effort were to evaluate the adequacy of the original PG&E structural and piping models and the computational techniques employed. Several discrepancies in the areas of mass calculations, model assumptions, and response spectrum smoothing techniques were found. The results were published in NUREG/CR-2834 entitled "Independent Seismic Evaluation of the Diablo Canyon Unit 1 Containment Annulus Structure and Selected Piping Systems," (USNRC, August 1982).

As it became apparent from the results of this study that discrepancies existed in the PG&E analyses, BNL was requested to expand its study to include the following additional analyses as described in SECY-82-414 (USNRC, October 13, 1982).

(1) a horizontal seismic analysis for the annulus structure

(2) a seismic and stress analysis of one buried diesel oil tank

(3) analyses for two additional piping systems (one within the Westinghouse scope and one within the PG&E scope)

These additional analyses were chosen to provide the staff with confirmatory information in areas that were not specifically included in the IDVP effort or the DCP Corrective Action Program at that time or to complement the previous BNL analyses efforts.

The results of the horizontal analysis of the containment annulus structure were presented in an NRC meeting with the IDVP and the DCP on February 15, 1983, and submitted to the staff in a letter from BNL dated May 17, 1983. It was concluded from this study that the flexibility and the torsional response of the annulus structure were important to the response calculations but had not been considered in the original PG&E analysis.

The results of the study of the buried diesel oil tank were presented in two NRC meetings with the IDVP and the DCP on June 17 and July 6, 1983, and were reported to the staff in a letter from BNL dated July 18, 1983. It was found in this effort that the original PG&E model used by Harding Lawson Associates

(HLA) in the analysis for the buried tanks was inadequate and led to substantial reductions in the stresses.

The analyses for the two additional piping problems were limited to the computation of natural frequencies and mode shapes. There was generally good agreement between the values obtained from the BNL analyses and those from the original PG&E analyses. The results of this study were reported to the staff in letter from BNL, dated April 11, 1983.

Details of each of these BNL analyses are discussed in further detail in Section 3.6 of this report.

3.1.5 Diablo Canyon Project Internal Technical Program

The Diablo Canyon Project (DCP) of PG&E in early 1982 initiated its own Internal Technical Program (ITP). The primary objectives of the ITP as stated by the DCP were to (1) provide an additional design review effort to ensure the overall adequacy of the analyses and design of the plant, (2) develop data and information in support of the IDVP, (3) respond to IDVP open items and findings, and (4) implement design modifications or other corrective actions arising from the IDVP and the ITP. The scope of the ITP was expanded from an initial sampling approach to a comprehensive design review of the plant's safety-related structures, systems, and components. Except as otherwise noted and justified, the criteria and the dynamic analysis procedures and methods used by the ITP were taken from the FSAR and its amendments and were described in Sections 3.7 of the SER and Supplements 7 and 8 to the SER. To date, modifications have taken place in the containment annulus structure, fuel handling building, intake structures, turbine building, piping supports, main control board, and some other areas. The modifications will be further addressed in the evaluation of individual buildings, systems, and components given in the following sections.

3.2 Structures

3.2.1 Containment Annulus Structure

3.2.1.1 Introduction

The annulus structure is a seismic Class I structure located inside the containment between the crane wall and the containment shell. It is attached directly to the crane wall, which provides lateral support, but is not connected to other parts of the containment. The annulus structure is a welded and bolted, structural steel frame extending from el 91 ft (top of base slab) to 140 ft. Radial and tangential beams of the annulus structure support piping, equipment, and walkways. The three lower floor levels (el 101 ft, 106 ft, and 117 ft) are structural steel, and the floor at el 140 ft is a composite concrete and steel deck with a nonmoment-resisting connection to the top of the crane wall. Some of the beam-to-column connections at the lower elevations are moment resisting. Radial beam to crane wall connections are bolted.

The primary sources of the data used by the staff in its evaluation are

(1) the IDVP Diablo Canyon Nuclear Power Plant - Unit 1 Final Report

(2) the Pacific Gas and Electric Company Phase I Final Report Design Verification Program

(3) technical interchange meetings between the IDVP and DCP as documented in the staff trip reports

(4) BNL independent evaluations as documented in NUREG/CR-2834 (the BNL report) and related letter reports

In the original design, PG&E had used a five-frame dynamic model for the vertical analysis of the annulus structure. Eighteen radial frames of the structure were consolidated into five frames, for modeling purposes, which represented the area halfway between each of the five fan coolers located on the concrete floor at el. 140 ft. The tangential beams between the 18 individual frames were not represented in the dynamic model. The crane wall was modeled as a rigid member so the five frames were essentially independent and uncoupled. After the "diagram error" was uncovered, the five-frame model analysis was revised. The revised PG&E model, also referred to as the 1981/1982 URS/Blume model, included corrected mass data, increased nodes on the radial elements, and more realistic representations of the structural connections.

3.2.1.2 Brookhaven National Laboratory Analysis

The NRC engaged BNL to perform an independent seismic analysis of the annulus structure. The BNL vertical seismic analysis utilized a three-dimensional model and time-history dynamic analysis techniques. The model included most of the structural steel members; therefore, many local modes of vibration were computed. The tangential beams were found to respond to the earthquake excitation and affected the floor response spectra. In a letter dated July 1, 1982, NRC requested TES to review the validity of the findings presented in the BNL report and the specific concerns raised therein as part of the Phase I verification effort.

BNL also performed a three-dimensional, time-history analysis for horizontal excitation. The crane wall, which is more flexible in the horizontal direction, was included in this model. The results of this analysis were presented to the IDVP at a meeting on February 15, 1983, and documented in a letter from BNL to the staff dated May 17, 1983. This analysis showed that the flexibility of the annulus steel was important for the horizontal response. The spectral acceleration at the crane wall was much lower than those on the steel portion of the annulus structure. The study also showed that input in one direction produced a significant response in the other direction. This response is produced by the torsion in the annulus steel frame.

3.2.1.3 IDVP Effort

The IDVP performed a field walkdown inspection of the annulus structure to verify the as-built condition. The IDVP also reviewed in detail the 1981/1982 URS/Blume five-frame model, also known as the Blume analysis, and the BNL three-dimensional model used to analyze vertical excitation. Additional IDVP studies included simple one and two degrees of freedom lumped mass modules to examine tangential beam flexibility as a factor in the generation of response spectra.

The IDVP verification efforts have not been completed as of June 30, 1983. The results and conclusion will be reported in a future ITR. However, the following in-process conclusions have been presented in the IDVP Final Report with regard to the PG&E analyses:

(1) The frame consolidation did not adequately represent the structure at el 101 and 106 ft.

(2) Tangential beam flexibility is an important factor in the response spectra generation.

With respect to the BNL analyses the IDVP concluded:

(1) There are no significant differences in the computed masses and member joints between the Blume analysis and the BNL analysis.

(2) The joint characteristics in the Blume analysis realistically represent the as-built configuration.

(3) The spectra smoothing technique applied by PG&E is consistent with the DCNPP licensing criteria.

Three EOIs were issued specifically pertaining to the annulus structure (3006, 3007, and 3008). These EOIs were combined with EOI 1014, which encompasses the verification of DCP corrective action for the containment annulus steel structure and the interior and exterior concrete structure.

3.2.1.4 DCP Effort

The DCP has implemented an extensive Corrective Action Program and the annulus structure has been reanalyzed to account for the concerns raised in EOIs 3006 and 3007. The seismic analysis and design of the containment and internals were reviewed by the DCP to ensure that the models used previously in the Hosgri, DE, and DDE analyses represent the as-built conditions. Based on this review, new model DE, and DDE properties for the annulus structure were developed and this structure was reanalyzed. As a result of this reanalysis, new response spectra for the annulus structure were developed.

The vertical response for the Hosgri event was determined by a time-history, modal superposition analysis of lumped-mass models of individual radial frames with single-degree-of-freedom oscillators to model the response of tangential framing. Coupled models incorporating both the concrete internal structure and the steel annulus structure were used. Masses for the internal concrete structure are lumped at el 140 and 114 ft. The crane wall serves as a common support for the individual frames, each frame carrying its proportion of the load of a fan cooler at el 140 ft and of various pipes at lower levels. The vertical response for DE and DDE earthquake accelerations for the platforms was taken as 2/3 of the zero period acceleration (ZPA) values from the horizontal ground motion spectra as stated in the FSAR.

The response of the annulus structure to horizontal input was reviewed by using analytical models of each main elevation. The natural frequencies of each elevation were evaluated and compared with the 20-Hz proposed criterion. If any of these frequencies had been below 20 Hz, appropriate modifications would have been made to increase these frequencies to above 20 Hz. No additional acceleration response spectra were generated for structural models with fundamental frequencies above 20 Hz. The horizontal acceleration response spectra developed in a separate analysis of the internal concrete structure are considered applicable for the horizontal analyses of subsystems attached to the various annulus steel elevations.

The annulus structure was modeled for an equivalent static structural evaluation using the STRUDL computer program. Each main elevation was modeled as a braced-frame, continuous structure based on the as-built conditions determined by field inspection. The models of each section were loaded with the pipe, equipment, gravity loads, and the appropriate seismic factors. The frames were then statically analyzed for displacement, stresses, and forces. Special emphasis was placed on evaluation of the frame members and connections for the effects of torsional and lateral loads introduced by the piping systems.

The average yield strength of steel, not to exceed 70% of the corresponding ultimate strength and the average 28- or 60-day concrete cylinder strength of the in-place materials, was used in lieu of the specified minimum properties for load combinations including Hosgri seismic loads. For load combinations involving DE and DDE, the specified minimum material properties were used. Normal working stresses without the 1/3 increase for seismic loads were used when the load combinations included DE. For load combinations that included Hosgri or DDE, the working stresses applicable to the operating condition were increased by a factor of 1.7.

The DCP verification for the annulus structure showed that the structure can withstand all applied loads and loading combinations, and will remain within the design limits after modification.

3.2.1.5 IDVP Verification of DCP Corrective Actions

The IDVP design review included assessments of the completeness, applicability, and consistency of the DCP review and reanalysis methodology. The DCP supplied a calculation index which documented the qualification analyses and computer files of record and served as the basis for selection of the IDVP sample of DCP qualification analyses. The IDVP selected two vertical seismic analyses and two horizontal frequency analyses of the DCP files for review. The IDVP plans to sample additional files relative to member evaluation when such files are available. The IDVP has not issued any EOIs for the annulus structure with regard to the DCP Corrective Action Program.

The IDVP verification effort regarding the containment annulus structure has not been completed at this time. The IDVP considers the following aspects of the DCP effort to be unresolved issues:

(1) whether the horizontal floor response spectra developed for the annulus structure properly reflect the dynamic characteristics of the interior structure

(2) whether the physical modifications in progress to stiffen the annulus structure for horizontal excitation will ensure compliance with the proposed criterion that the minimum frequency be 20 Hz

The IDVP intends to formulate a final conclusion as to the qualification of the annulus structure and its conformance to licensing criteria when all analyses have been evaluated by the IDVP. This evaluation and conclusions by the IDVP will be reported in a future ITR.

3.2.1.6 Staff Evaluation

IDVP Effort

Based on the insights gained through the BNL analysis of the annulus structure as well as the review of the mathematical models, calculations, and drawings in addition to the staff field observations, the staff finds that the IDVP for the containment annulus structure was effective in ensuring that the dynamic response of the structure and attached and supported equipment will be adequately defined. It is noted, however, that while the use of free-hand averaging of peaks and valleys in the spectra previously has been accepted by the staff, the smoothed curve should be a reasonable average but not a lower bound. Also, its use should be limited to frequencies away from structural frequencies (peaks of the curve). The staff review is not yet complete. However, the staff will review the future ITRs before reaching a conclusion.

DCP Effort

Based on the BNL independent analyses as well as on the technical audit of ongoing work, the staff finds the DCP reverification to be extensive and professionally executed. It is noted, however, that a frequency of 20 Hz should not be considered as a frequency in the rigid range without verification. The Newmark Hosgri spectra approach ZPA at 33 Hz. It is the staff's position that the use of the 20-Hz cutoff frequency for generation of floor response spectra should be verified and/or justified. With the exception noted, the results should lead to the acceptance of the annulus steel structure if the program was carried out properly. The IDVP review will verify the accuracy of the DCP program. The staff will reach its conclusion after the review of the future IDVP ITRs.

3.2.1.7 Conclusion

The IDVP review has not been completed at this time. Additional information will be submitted by the IDVP at a later date. The staff considers the 20-Hz cutoff frequency for generation of floor response spectra an open issue and will require that the IDVP review verifications and/or justifications provided by the DCP and include the results of review in future reports.

3.2.2 Containment Interior Structure

3.2.2.1 Introduction

The containment interior structure consists of three major components, the crane wall, reactor cavity wall, and fuel transfer canal. The 106-ft outside-diameter crane wall is 3 ft thick and extends vertically from the base slab at el 91 ft to the operating floor at el 140 ft. The polar crane is supported on the crane wall at el 140 ft. The wall also serves as a support for the annulus platforms, interior platforms, and floor slabs. The area inside the crane wall houses the steam generators, the recirculation pumps, the pressurizer, and related equipment. This area acts as a barrier to missiles and jet impingement forces produced by postulated pipe rupture. The crane wall also helps to support the ends of the fuel transfer canal, the steam generator shield walls, and other structures above el 140 ft.

The reactor cavity wall, which is at the center of the containment building, encloses and supports the reactor vessel. This circular concrete wall has an outside diameter of 34 ft, varies in thickness from 3.5 to 8.5 ft, and extends from the base mat at el 91 ft to the top of the floor slab of the fuel transfer canal at el 114 ft.

The fuel transfer canal is a reinforced concrete box with an open top, supported at the ends by projections from the circular crane wall and at the center by the reactor cavity wall. The interior surface of the canal is lined with stainless steel plate. The canal holds borated water during refueling and fuel transfer operations. The fuel transfer canal interfaces with the fuel transfer tube at the containment wall

The primary sources of data used by the staff in its evaluation are

(1) the IDVP Diablo Canyon Nuclear Power Plant - Unit 1 Final Report

(2) the Pacific Gas and Electric Company Phase I Final Report Design Verification Program

(3) technical interchange meetings between the IDVP and PG&E as documented in the staff trip reports

3.2.2.2 IDVP Effort

The IDVP verification consisted of examining samples of the DCP verification analysis. The DCP supplied a calculation index that documented the qualification analyses and computer files of record and served as the basis for selecting the IDVP sample of DCP qualification analyses.

The IDVP had a number of technical meetings with the DCP to discuss the DCP methodology, criteria, and analytical results. Major topics at these meetings included the polar crane evaluation and the interior structure floor response spectra generation.

The IDVP selected a sample of the DCP qualification analyses to assess conformance to licensing criteria, accuracy of calculations, and the essential steps of the qualification process. A design review checklist was developed by the IDVP to ensure that all necessary items were examined and documented. In addition to the checklist, the IDVP design review included assessments of the completeness, applicability, and consistency of the DCP review and reanalysis methodology.

The IDVP chose the following areas of the containment interior structure for review:

(1) reactor cavity wall member evaluation considering compartment pressure, reactor vessel seismic loads, etc.

(2) reactor ring support evaluation

(3) polar crane-dynamic solution and member evaluation, is including evaluation of the main crane components such as bridge girder, crane legs, guide struts, and rail capacity

One EOI (1009) was issued by the IDVP as a result of this verification. The EOI dealt with nonavailability of floor response spectra above the floor at el 140 ft. Because the DCP was reanalyzing the containment, this EOI was combined into EOI 1014 for tracking purposes. No additional EOIs were issued by the IDVP as a result of its review as of June 30, 1983.

The IDVP review is not yet complete. On the basis of the efforts performed up to June 30, 1983, the IDVP considers that the following aspects of the DCP work are acceptable and satisfy the licensing criteria:

(1) The analyses of the containment structure reflected as-built conditions with conservative assumptions incorporated into the analyses. Pressure and temperature were properly applied.

(2) Numerical accuracy of the calculations sampled was satisfactory. Minor discrepancies were noted in such areas as determination of section properties, but had no significant impact on results.

(3) Analysis and qualification of the reactor cavity wall were satisfactory.

The verification effort of the IDVP is not complete; however, the IDVP considers the following item to be unresolved - calculation of interior structure horizontal floor response spectra.

The final conclusions as to the qualification of the containment interior structure and polar crane will be reported by the IDVP in a future ITR.

3.2.2.3 DCP Effort

The horizontal model of the containment for DE and DDE is an axisymmetric, finite element model which includes the exterior shell, internal structure, base slab, and rock mass. The exterior shell and the internal structure are coupled by the base slab and the foundation rock elements; thus, the model is used for both structures. The DE and DDE vertical analysis was a static analysis using 2/3 of the zero period acceleration of the horizontal ground response spectra.

The horizontal model for the Hosgri event was the same model used for the DE and DDE analysis except a fixed base was used. In addition, two lumped-mass models were used for torsional response because of geometric and accidental eccentricity. The two models are fixed base and correspond to 5 and 7% accidental eccentricity, respectively.

The vertical model of the containment internal structure is a lumped-mass, coupled model, including both the concrete internal structure and the annulus steel frames which correspond to the locations of the five fan coolers at el 140 ft. The concrete internal structure is represented by one leg of each frame. The concrete mass of the interior is lumped at el 114 and 140 ft. The steel frames have a common support at the crane wall, and each carries the mass of one fan cooler at el 140 ft, plus any additional attached masses at the various elevations. This model was developed during the original Hosgri evaluation, and is used for determining responses in the concrete portion of the internal structure.

The dynamic analyses for the DE and DDE horizontal model used input motion at the model rock boundaries that produced the required response spectra at the rock/base slab interface. The input motion for the Hosgri models, both horizontal and vertical, was applied directly to the base of the model.

Dynamic analyses using time-history, modal superposition techniques were performed. These analyses were then used to produce floor spectra for piping and equipment evaluation as well as to supply moments and forces for the structural design. Structural damping values of 2 and 5% in the DE and DDE analyses, respectively, and 7% damping for the foundation rock were used in both analyses. A cutoff frequency of 20 Hz was used for all spectra.

For the Hosgri evaluation, structural damping of 7% was used. The horizontal-torsional models account for the actual geometric eccentricity plus an accidental eccentricity equal to either 5% or 7% of the building dimension. The horizontal motion resulting from torsional response is combined with the purely horizontal motion on the absolute sum basis for the 5% eccentricity case, and by the square-root-of-the-sum-of-the squares sum for the 7% eccentricity case. The 5% eccentricity case is found to govern at all radii from the structure centerline.

The vertical response was computed using the coupled internal concrete-plus-annulus model. There was no amplification for the concrete portion of the structure. A cutoff frequency of 33 Hz was used for all spectra.

The following specific areas were identified and verified:

(1) Weights of the structure and equipment were recalculated based on as-built conditions. The recalculated weights agree well with those used in the analysis.

(2) Section properties and stiffnesses of the models were compared with as-built conditions.

(3) As-built support conditions of major equipment were reviewed to verify that the equipment weights were correctly apportioned in the vertical and horizontal models.

(4) The as-built configuration was reviewed to verify the fixity conditions within the vertical model of the internal structure.

(5) The internal structure above the operating deck at el 150 ft was modeled separately and analyzed using the time history obtained from the primary model analysis.

The DCP performed a comprehensive review of the overall design of the internal concrete structure. In addition to the dead, live, and seismic loads, the design loads also included loads from the postulated loss-of-coolant accident. These consisted of compartment pressurization, pipe rupture and equipment support sections, jet impingement loads, and missile loads.

For the reactor cavity wall the DDE seismic loads were found to govern over the Hosgri values. The structure was found to be adequate for the load combinations.

The reactor vessel imparts vertical (downward only) and horizontal loads on the reactor support ring at four locations. The steel support ring and the concrete portion of the cavity well that supports the ring was checked for abnormal loading conditions. The structure was found to be adequate for these loads.

Other major sections of the internal concrete structure, including the circular crane wall and fuel transfer canal, floor slab at el 140 ft, steam generator shield walls, and walls around the pressurizer, were included in the review. The results of these reviews indicated no structural elements were above the allowable stress values.

3.2.2.4 Staff Evaluation

<u>IDVP Effort</u>

The IDVP verification consisted of a review of selected samples of the DCP evaluation. The results of this review as documented in the IDVP Final Report indicate that the DCP verification effort is on track. The results of the IDVP effort will be documented in a future ITR. The staff will evaluate the results of the IDVP effort as they become available.

<u>DCP Effort</u>

The verification analysis by the DCP incorporated an apparently complete reanalysis of the containment interior structure, including recalculation of seismic loads. Member evaluations were made using the load combinations specified in the FSAR. The staff will render its findings on the DCP verification after the IDVP review of a future ITR on this subject.

3.2.2.5 Conclusion

The staff will formulate a conclusion on the containment interior structure verification once it reviews the IDVP ITR on the verification of the DCP corrective action.

3.2.3 Containment Exterior Shell

3.2.3.1 Introduction

The containment exterior shell consists of a reinforced concrete cylinder, 142 ft high, capped with a reinforced concrete hemispherical dome. The cylinder wall is 3 ft 8 in. thick, and the dome is 2 ft 8 in. thick. Both have an inside diameter of 140 ft. The base of the containment is a reinforced concrete circular slab 153 ft in diameter and 14 ft 6 in. thick. The inside of the dome, cylinder, and base slab is lined with a leaktight membrane of welded steel plate. The liner is 3/8 in. thick on the cylinder wall and dome, with the exception of a 3/4-in.-thick liner plate near the bottom of the cylinder wall and 1/4-in. thickness on the base slab. There is a 2-ft-thick concrete floor slab on top of the 1/4-in.-thick liner plate. The basemat is poured directly against the underlying rock foundation.

The piping and electrical connections between equipment inside the containment structure and other parts of the plant are made through leaktight containment penetrations. Other penetrations are the 18-ft-6-in.-diameter equipment hatch, the 9-ft-7-in.-diameter personnel hatch, the 5-ft-6-in.-diameter emergency personnel hatch, and the fuel transfer tube.

The primary sources of the data used by the staff in its evaluation are

(1) the IDVP Diablo Canyon Nuclear Power Plant - Unit 1 Final Report

(2) the Pacific Gas and Electric Company Phase I Final Report Design Verification Program

(3) technical interchange meetings between the IDVP and PG&E as documented in the staff trip reports

3.2.3.2 IDVP Effort

The IDVP verification of the containment exterior shell consisted of examining, on a sampling basis, analyses for seismic and certain nonseismic loads. The seismic loads were the DE, DDE, and Hosgri events; the nonseismic loads were pressure, temperature, pipe reaction, jet impingement, missile, and dead and live loads. The details of the IDVP verification will be reported in a future ITR.

For the containment exterior structure the DCP reviewed and accepted the original seismic analyses. The DCP then used these results and performed member evaluation calculations. The DCP performed reanaylsis of the equipment hatch region and the base slab/shell junction, as well as the base slab. The DCP provided the IDVP with a calculation index which documented the qualification analyses and computer files of record and served as the basis for selection of the IDVP sample of the DCP qualification analyses.

The IDVP conducted a number of technical interchange meetings with the DCP to discuss the DCP methodology, criteria, and analytical results. Major topics at these meetings included, among other containment topics, the qualification of the external shell including the equipment hatch and the shell/base junction. The IDVP selected a sample of the DCP qualification analyses to assess conformance to licensing criteria, accuracy of calculations, and the essential steps of the qualification process. The IDVP review included assessments of the completeness, applicability, and consistency of the DCP review and reanalysis methodology.

The sample files chosen by the IDVP for review were

(1) seismic analysis (Hosgri) and member evaluation for the containment shell considered as an axisymmetric structure

(2) a sample of the computer results for a specific load combination

(3) base slab/shell junction member evaluation of adjacent slab and shell elements, steel meridional soldier beams, rebar, etc.

No EOIs were issued as a result of the review of the DCP verification work; however, the IDVP issued one EOI against the containment exterior as a result of its initial investigation at the beginning of the IDVP effort. This EOI (1014) is classified as error class A/B. The EOI is still open because it has been combined with several other EOIs that pertain to the entire containment structure.

The IDVP review was not complete as of June 30, 1983. However, the IDVP considered that the following aspects of the DCP work are acceptable and satisfy the licensing criteria:

(1) The analyses of the containment structure reflected as-built conditions with conservative assumptions incorporated into the analyses. Pressure and temperature loadings were properly applied.

(2) Numerical accuracy of the calculations sampled was satisfactory. Minor discrepancies were noted in such areas as determination of section properties, but had no significant impact on results.

(3) Analysis and qualification of containment exterior shell under various load combinations (as given in the FSAR and the Hosgri report), except in the vicinity of the equipment hatch, were satisfactory.

The IDVP considers the following aspect of the DCP work to be an unresolved issue at this time - analysis and qualification of the containment shell in the vicinity of the equipment hatch.

3.2.3.3 DCP Effort

The DCP reviewed the previous Hosgri, DE, and DDE seismic models to ensure the models represented the as-built conditions. Based on this review, new model properties of the annulus structure were developed and used for reanalysis. The previous Hosgri seismic model was a fixed-base, finite element model of the entire containment. This model contained the exterior shell and the interior structure of the containment, but which were uncoupled. The seismic model used for the DE and DDE analysis was also a finite element model but included the base rock. This model couples the exterior shell and the interior structure through the base slab and the foundation rock elements and thus was used for the analysis of both the structures. The model for the Hosgri evaluation considered 5% and 7% accidental eccentricity. These models satisfied the licensing criteria as contained in the FSAR.

The seismic loads in combination with other loads as specified in the FSAR load combination equations were used as the input to a concrete anaylsis program to determine the local structural forces. Six typical representative sections were selected for review. These sections represented the dome, upper transition zone between the dome and cylindrical wall, the spring line, the mid-height of the cylindrical wall, and the bottom of the cylindrical wall. The calculated stresses in the liner plate, rebars, and concrete were tabulated and compared to the allowable limits. The stresses were determined to be within the allowable limits.

The connection between the containment exterior shell and the base slab was evaluated. The connection was designed to allow free relative rotation in any meridional plane while resisting meridional membrane forces and transverse shear. The evaluation of various structural elements in this region was performed by an axisymmetric finite element model.

An approximate hand calculation of the equipment hatch region indicated the need for additional analysis. A horizontal 90° sector, 60-ft-high section of the shell was modeled. The model was symmetric about the hatch center line both horizontally and vertically. The loads considered consisted of the dead load, internal pressure, thermal gradient, and two components of the horizontal seismic forces in combination with the vertical. Stresses were obtained as selected points for comparison, and isostress plots were obtained to show the stress variations around the hatch opening. Local yielding was observed in relative small areas of the steel plates around the opening for factored load combinations. The computed stresses closely matched the values obtained from measurements made during the structural integrity tests.

The verification of the liner plate system consisted of the development of allowable loads for attachment-threaded studs to qualify the mechanical or piping system. The load transfer mechanism from the external mechanical loads through the liner plate to the concrete stud system was developed to ensure the transfer of all loads into the concrete shell with all elements remaining elastic while maintaining a leaktight boundary.

The DCP analysis verification process identified and verified the following specific areas:

(1) Weights of the structure and equipment were recalculated based on as-built conditions.

(2) Section properties and stiffnesses of the models were compared with as-built conditions.

(3) The as-built support conditions of major equipment were reviewed to verify that the equipment weights were correctly apportioned in the vertical and horizontal models.

The results of the DCP for the containment exterior shell analysis are:

(1) The calculated stresses in the global containment exterior model for the liner plate, rebars, and concrete are within allowable limits and, therefore, are acceptable.

(2) The calculated stresses in the area of the exterior shell and base mat connection are less than allowable limits and, therefore, are acceptable.

(3) Local yielding was observed in relative small areas of the equipment hatch hexagonal plate adjacent to the penetration sleeve for the factored load combinations. Local yielding is allowed in Part 2 of the American Institute of Steel Construction (AISC) code. The equipment hatch is, therefore, acceptable.

3.2.3.4 Staff Evaluation

IDVP Effort

The IDVP verfication work on the containment exterior consisted of reviewing a sample of the DCP analysis. The IDVP considers the contaiment exterior shell to be acceptable except in the vicinity of the equipment hatch. The IDVP will provide its results on the containment exterior verification effort in a future ITR.

The staff agrees that a sample of the DCP work is sufficient for the IDVP to evaluate the DCP work. It is noted, however, that instead of the AISC Code used by the DCP, the design code for containment penetrations accepted in the original licensing documents was Section III of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code as indicated in Table 3.2-4 of the FSAR. In addition, the IDVP should evaluate the justification for the local yielding of the steel plates around the opening. The staff will further evaluate the IDVP effort when a future ITR on this subject becomes available.

DCP Effort

The DCP verification effort consisted of a review of the models for reflection of as-built conditions, comparison of analytical results, and assessments of the calculated stresses against allowable values. The containment shell was evaluated in several places for the global modal, the shell base mat junction, and the shell area around the equipment hatch.

The staff agrees that the procedures used thus far should lead to qualification of the shell, but the use of AISC code for containment penetration analysis and local yielding of steel plates should be justified.

3.2.3.5 Conclusion

The staff will formulate its conclusion regarding the acceptance of the containment exterior shell after the review of a future ITR on this subject.

3.2.4 Auxiliary Building

3.2.4.1 Introduction

The auxiliary building is a reinforced concrete shear wall structure with a steel-framed enclosure over the fuel handling area. The fuel handling building is discussed in Section 3.2.5. The building is essentially the shape of the letter "T" with the stem oriented in the east-west direction and the top of the T oriented in the north-south direction. The containments for Unit 1 and Unit 2 are located on either side of the stem. The building is approximately 500 ft north-south by 230 ft east-west and 90 ft high. The steel-frame portion over the fuel handling area is 48 ft tall. The building is founded on the underlying rock and soil material at three different levels. The stem of the T is founded on bedrock at el 55 ft. The area between the stem to outside the spent fuel pool is founded on competent rock at el 82 ft. The area outside the spent fuel pool is founded on compacted soil at el 97 ft. The interior of the structure contains many shear walls that do not form a consistent pattern throughout the height of the structure. The building contains major horizontal floor slabs at six different elevations.

The primary sources of data used by the staff in its evaluation of the verification of the auxiliary building are

(1) IDVP evaluation documented in ITR 6

(2) IDVP Diablo Canyon Nuclear Power Plant - Unit 1 Final Report

(3) Pacific Gas and Electric Company Phase I Final Report Design Verification Program

(4) technical interchange meetings between IDVP and PG&E as documented in the staff trip reports

3.2.4.2 IDVP Effort

The results of the IDVP review of the auxiliary building are documented in ITR 6 and the IDVP Final Report. The auxiliary building was chosen by the IDVP as the initial sample of a structure for the following reasons:

(1) The building contains the largest amount of safe shutdown piping, equipment, and components.

(2) The building itself supports the fuel handling building and the control room.

(3) The building is structurally complex, with both concrete shear walls and steel framing.

(4) There was a controversy between PG&E and URS/Blume regarding masses in the seismic model of the building during the 1977 analysis.

The scope of the IDVP review, as outlined in ITR 6, is:

(1) Review the URS/Blume horizontal models for the seismic analysis of the auxiliary and fuel handling buildings.

(2) Calculate and compare the building properties for the horizontal models.

(3) Calculate and compare natural frequencies and mode of vibration for the horizontal models.

The IDVP review of the auxiliary building seismic analysis revealed that although the structure had been modified between 1971 and 1977, the same model was used for three sets of analyses in 1971, 1977, and 1979. The 1977 analysis had omitted the soil spring in the north-south direction model. This oversight was corrected in the 1979 analysis. The IDVP used the same model (six lumped masses on a cantilever beam) as that in the original analysis but recalculated the model properties based on the drawings that existed in the PG&E files. Changes were made to model properties in the area of the fuel handling building to reflect the modifications made to the steel structure.

As a result of the IDVP analysis the following concerns were identified:

(1) The methodology used to calculate the bending moments of inertia in the design analysis was different from that used in the independent analysis. The resulting bending moments of inertia differ by more than the 15% trigger level used by the IDVP. The effect of this difference on important building periods is from 6% to 15%.

(2) Differences in the key properties calculations (fuel handling building stiffness, torsional rigidity, and centers of mass) and discrepancies between field and analyzed conditions suggest that design control measures were inadequate.

(3) Differences in the calculated values for soil springs were reported which have not been reconciled. Sensitivity studies indicate that the effects of variation of this parameter on important building periods is from 6% to 12%.

A total of 16 EOIs pertaining to the auxiliary building were issued by the IDVP. Six of the EOIs were for the fuel handling building and will be addressed in Section 3.2.5. Of the remaining 10 EOIs, only 1 (EOI 1097) was classified as error A or B. The EOI had to do with the nonavailability of the floor response spectra for the fan/machine room above el 163 ft. Because the DCP was completely reanalyzing the auxiliary building, the EOI was combined with several others and will be closed upon the IDVP review of the DCP reanalysis.

3.2.4.3 DCP Effort

The DCP reanalyzed the auxiliary building for the Hosgri event as well as the design earthquake (DE) and double design earthquake (DDE). The geometry of the models used to describe the seismic response of the auxiliary building was the same as that used for the original seismic analyses. The model was the lumped-mass type utilizing six concentrated masses. However, the parameters of the model which described the structure were redefined during the reanalyses to reflect the building as-built conditions. The model possesses displacement and rotation degrees of freedom at each node point for the horizontal direction; only the vertical displacement is retained as a degree of freedom for the vertical model. Soil springs are used in the horizontal models to represent soil/structure interaction effects for those portions of the structure which are not founded on rock.

In response to the staff's concern regarding the floor slab flexibility, the slabs in the building were surveyed using thickness and span criteria to determine the natural frequency. This survey resulted in findings that 12 of the slabs were flexible in the vertical direction (frequency less than 33 Hz). Detailed finite element models of these slabs using plate elements were made, and a time-history analysis of the individual slabs was performed to generate response spectra at critical locations in the slab. The time-history input to the slab model was the output from the closest point in the six-mass lumped parameter model of the entire building. Significant spectral amplifications were found in these slabs.

A structural evaluation of the slabs and walls for significant loadings was made. The loadings considered were the seismic, dead, and live loads. Original criteria of acceptance were taken from the American Concrete Institute (ACI) 318-63 Code and Structural Engineers Association of California (SEAOC) Code 1974 for slabs and walls, respectively. For the current evaluation a new criterion for shear walls was developed and used. This criterion is contained in Appendix 2a of the DCP Phase I Final Report and considers the following three possible failure modes: (1) exceedance of the shear friction allowable, (2) exceedance of the diagonal shear cracking allowable, or (3) exceedance of the flexural reinforcing stress allowable. Out-of-plane loads are not combined with the in-plane loads if the out-of-plane loads are less than 85% of the in-plane capacity.

Loads were distributed from the six-mass model to the floor slabs based on the rigid diaphragm assumption. The loads from the walls above the diaphragm (floor slabs), the inertial loading in the slab, and the loads in the walls below the slab must be in equilibrium. These loads in turn were used to calculate the shears and moments in the slabs. The shear forces in the walls were determined by the relative stiffnesses of the walls in a particular floor.

All of the slabs and walls were found to be acceptable by the DCP. The slabs were found to have factors of safety of 1.0 to 1.4 for the DE, 1.4 to 2.2 for the DDE, and 1.1 to 2.0 for the Hosgri earthquake. The acceptance criterion was the ACI 318-63 Code. The factors of safety for the walls were found to be 2.1 to 3.0 for the DE, 1.8 to 2.8 for the DDE, and 1.1 to 1.9 for the Hosgri earthquake. The acceptance criterion was the ACI 318-77 Code with modifications as described in Appendix 2a to the DCP Phase I Final Report.

The horizontal load capacity of the floor slabs was shown to have a value greater than the demand of the following capacity/demand ratio of 1.04 as a low to 3.4 as a high, except for one section which had a ratio of 0.45. This ratio indicates that for the loads calculated, the slab is overstressed in this area. The DCP cited the assumption of rigid diaphragm behavior for the seismic model and simultaneous occurrence of maximum forces resulting from translation and torsion at each level. The rationale for acceptance by the DCP is that maximum forces do not occur at the same instant in time and the structure is capable of redistributing the loads to less heavily loaded sections because the structure is ductile and the demand on the entire section is less than the total section capacity.

During technical interchange meetings between the IDVP, DCP, and the NRC staff, several concerns were raised regarding the analysis of the auxiliary building. Concern has been expressed over the appropriateness of the six-mass model used to represent the structure in the seismic analysis. In particular, the model is based on the assumption that the floor slabs (diaphragms) are rigid in their own plane (the horizontal direction) as compared with the walls' stiffness in the horizontal direction. The DCP reported on several studies directed at this issue during technical interchange meetings between the IDVP and DCP.

In one of these studies, a three-stick model was generated which included floor slab flexibility in the vicinity of the spent fuel pool. The DCP performed a parametric study with the slab flexibility varied from rigid through actual to zero. The results of this DCP study indicated that the floor slab flexibility did not have a significant effect on the structural response. A second study reported by the DCP involved a complex three-dimensional model of the auxiliary building using plate elements to describe the floor slabs and interconnecting walls. The stated purpose of this model was to obtain a better distribution of the floor loadings between the various floor slabs.

Another topic discussed at many of the technical interchange meetings was the soil springs used to model the connection of the building foundation to the soil at el 100 ft. Questions had arisen regarding the soil properties used to evaluate the springs that were used in the general models. The DCP had performed parametric studies that indicated the response of the building to the earthquake was not significantly affected by variations in these springs for a range of possible values. The IDVP on the other hand had also performed parametric studies for the same problem which led to results that did not agree with the DCP results.

3.2.4.4 Staff Evaluation

IDVP Effort

The limited independent seismic analysis by the IDVP pointed out several areas of concern about the PG&E Hosgri seismic analysis. The results of the IDVP analysis was documented in ITR 6. This report was evaluated by the staff and an audit of the background material was conducted on October 27 and 28, 1982. The staff generally agreed with the analysis, but a couple of areas were found to be questionable. The staff found that:

(1) The use of horizontal half-space soil spring formulation to compute the soil springs for the embedment effects was inappropriate.

(2) The method of incorporating the shear walls into the moment-of-inertia calculations was not consistent with the assumptions of the seismic model.

(3) The soil data used in the analysis should be verified.

The results of the IDVP evaluation of the DCP reanalysis are expected to be issued in a future ITR.

DCP Effort

The staff finds that the seismic analysis of the auxiliary building by the DCP was in general well done and should produce reliable results. The parametric studies presented at the technical interchange meetings provided insight into the sensitivity of the various parameters used in the seismic analysis.

The acceptance criteria used by the staff to evaluate the work of the DCP is contained in the FSAR and applicable amendments to the FSAR with respect to the Hosgri event. The staff finds the following areas need to be resolved:

(1) The seismic model used by the DCP to predict the structural loads and produce the floor response spectra is of the generally accepted type for normal seismic analysis. However, the model has many simplifications and inherent assumptions. One assumption is that the floor slabs are rigid as compared to the walls. If floor-slab flexibilities are to be used as justification for accepting an overstress condition, then these flexibilities should be incorporated into the dynamic model used to predict the structural loadings or show the flexibilities to be unimportant.

(2) The use of different versions of the ACI 318 Code for evaluation of the floor slabs and walls is not appropriate. The versions ACI 318-63 and ACI 318-77 are not the versions committed in the Hosgri evaluation criteria outlined in the FSAR. The use of the different versions of the code and the modifications to the 1977 code as described in Appendix 2a to the DCP Phase I Final Report should be justified by the DCP and evaluated by the IDVP.

(3) The discrepancy between the IDVP and the DCP sensitivity study of the soil spring influence on the seismic response should be reconciled. Also the values of the soil properties should be resolved.

3.2.4.5 Conclusion

The staff concludes that the efforts by the IDVP were sufficient to identify deficiencies in the qualification of the auxiliary building. The IDVP evaluation of the DCP verification analysis is not available at this time for staff review and comment. However, based on the information presented by the DCP in the PG&E Design Verification Program Phase I Final Report, the staff has listed three concerns above that should be addressed by the DCP and evaluated by the IDVP. The staff also requires that the DCP formally document all the parametric studies performed and used to demonstrate the adequacy of its assumptions on slab flexibility and the soil springs.

3.2.5 Fuel Handling Building

3.2.5.1 Introduction

The fuel handling building is a seismic Class I steel-framed structure supported on the eastern portion of the auxiliary building at the el-140-ft floor slab. The steel frame supports a fuel handling bridge crane (capacity of 125 tons) and an auxiliary crane (capacity of 125 tons) and houses areas related to the fuel pool. The steel frame measures 366 ft long by 58 ft wide by 48 ft high. The steel structure is the mill building type with cross-braced columns in the north-south direction and moment resistant frames in the east-west direction. A portion of the end frames are anchored on top of a 24-ft-high concrete wall common with the exhaust fan rooms in the auxiliary building. The roof is a trussed and cross-braced diaphragm covered with metal decking and builtup roofing.

Because the structure is designated as seismic Class I, it must be qualified for postulated seismic events. Therefore, the structure was evaluated for the DE, DDE, and Hosgri events in combination with other loadings as required by the FSAR commitments.

The primary sources of the data used by the staff in its evaluation are

(1) IDVP evaluation as documented in ITR 6

(2) IDVP Diablo Canyon Nuclear Power Plant - Unit 1 Final Report

(3) Pacific Gas and Electric Company Phase I Final Report Design Verification Program

(4) technical interchange meetings between the IDVP and PG&E as documented in the staff trip reports

3.2.5.2 IDVP Effort

The IDVP verification of the fuel handling building consisted of examining on a sampling basis the DCP analysis for both the seismic and nonseismic loads. The IDVP developed a design review checklist of the items to be examined and documented the results. The review included assessments of the completeness, applicability, and consistency of the DCP review and reanalysis methodology. The IDVP performed calculations where necessary to assess the effects of various DCP assumptions and calculations. The IDVP did not perform a separate analysis of the fuel handling building, but reviewed the following samples:

(1) methodology and procedures used in the formulation of the dynamic and equivalent static models

(2) geometry and member properties used in the models

(3) free vibration analysis of the dynamic models to determine dynamic characteristics

(4) time-history analyses (Hosgri) of the dynamic models which produced response spectra and provided accelerations for use in the equivalent static model, including the input time history from el 140 ft of the auxiliary building

(5) evaluation of the nodal accelerations used to determine equivalent static loads

(6) computation of loads for the equivalent static analysis and a sample of the computer runs for a static analysis load case

(7) comparison of selected member loads with member allowable loads for the postulated Hosgri event

The IDVP-selected sample included approximately 50% of the structural dynamic analyses, the static analysis, and member evaluation. The crane was not included in the dynamic analysis sample. The IDVP did not review the preliminary static model the DCP used in the analysis to determine the modification requirements. No EOIs were issued for the fuel handling building with regard to the DCP Corrective Action Program. Six EOIs were issued as a result of the original IDVP evaluation of the fuel handling building. Five EOIs were classified as error class A. All of the EOIs pertain to differences between the design drawings and the as-built configuration. Four of the EOIs were combined into the remaining EOI 1092 and will be closed by the IDVP final verification of the as-built structure.

The verification program conducted by the IDVP was not complete as of June 30, 1983. However, the IDVP considers that some portions of the DCP work are acceptable and satisfy the licensing criteria. These portions are listed below. The IDVP will formulate final conclusions when the DCP modifications and IDVP field walkdowns for verifications of the as-built conditions against designs are complete. The IDVP will report the results in a forthcoming ITR. The IDVP finds the following items acceptable at this time:

(1) omission of an allowance for accidental eccentricity in the fuel handling building because the torsional effects are accounted for in the auxiliary building response at el 140 ft

(2) the ranges of crane locations and assessment of their effects

(3) the dynamic models used in the fuel handling building evaluation

(4) response spectra generation

(5) equivalent static loads determined from the dynamic acceleration profiles

(6) qualification of members and connections

3.2.5.3 DCP Effort

The DCP performed a complete seismic analysis of the fuel handling building and crane using the criteria contained in Section 3.0 of the FSAR for DE and DDE loads. The evaluation for the Hosgri event used the criteria contained in Sections 4.1 and 4.3 of the Hosgri report as contained in FSAR Amendment 50.

The DCP did a preliminary review of the fuel handling building which consisted of a field investigation of as-built conditions, review of the applicable criteria, and a simplified analysis of selected portions of the structure. This review indicated the previous analyses had not produced conservative results. Given this condition the DCP developed more detailed models and performed a structural evaluation.

Three finite element models were used to perform the analyses of the fuel handling building. Each of the models was made up of three-dimensional beam/truss elements having up to six degrees of freedom per joint. The materials used for the Hosgri analyses were based on as-built material properties. The computer solutions for each of the models was obtained using the STARDYNE computer program.

The first model was a complete model of the entire structure and was used to perform static analyses. Static loads (e.g., crane loads) were input directly to this model to obtain member loads. Equivalent inertial loads were input to this model to obtain seismic-induced member stresses. The magnitude of the inertial loadings was obtained from the detailed dynamic analyses performed with the second and third models.

The second and third models were generated to perform the seismic response calculations. One of these modeled the end 6 bays of the 18-bay structure; the other modeled the middle 6 bays of the structure. For each of these models the dynamic degrees of freedom (DDOF) were specified and a time-history analysis of the seismic response of the structure was performed. About 20 DDOF were used for the horizontal analyses; 31 DDOF were specified for the vertical analyses. The input time history was obtained as the output from the seismic analysis of the auxiliary building at el 140 ft. Several analyses were performed for the auxiliary building with varying eccentricities. The time history having the largest content at the frequency ranges of interest to the fuel handling building was selected for these analyses. Output from these analyses consisted of floor response spectra at locations of interest and global accelerations which were used to generate the equivalent inertial loading to be applied to the first model so that member seismic forces could be determined.

The results of this analysis indicated certain structural modifications were needed to meet the acceptance criteria contained in the FSAR. After the modifications were designed, the structural models were modified to reflect the structural changes and the analysis was redone. The members were then either reevaluated or it was shown that the member loads decreased as a result of the design modification. All members were shown to satisfy the acceptance criteria. The modifications generally involved the stiffening of most bracing systems and strengthening of connections to meet the acceptance criteria.

During the technical interchange meetings between the IDVP, DCP, and the NRC staff, concerns were expressed regarding the use of output from the auxiliary building analysis as input to the base of the fuel handling building. The output from the auxiliary building analysis consists of a translation component plus the rotational component times the distance from the center of rotation of the auxiliary building to the point of application on the fuel handling building. Uncertainties exist because of the large dimensions of each of the structures. The DCP reported at the technical interchange meetings that, on the basis of parametric studies, its treatment of this program was adequate. These studies are not contained in the DCP Phase I report.

3.2.5.4 Staff Evaluation

IDVP Effort

The IDVP sampling of the fuel handling building was sufficient to identify inconsistencies in the structural analysis of the design. Although the IDVP did not perform an independent design analysis, the calculations were sufficient to highlight areas of concern. The field verification of the design against the as-built structure was sufficient to show deficiencies in the structure as evidenced in the ITRs and the IDVP Final Report.

The verification effort of the IDVP for the fuel handling building is not complete because the DCP is still performing reanalysis and modifications. The IDVP currently is reviewing the DCP calculation packages. When this IDVP review is finished and the field verification is completed, the IDVP will present the results in a future ITR.

DCP Effort

The reevaluation by the DCP consisted of a complete analysis of the existing fuel handling building structure. It included field verification of the existing structural configuration, generating a detailed computer model of the structure, performing a dynamic and static analysis, and performing member evaluations. If modifications were determined to be necessary, they were made and the structure was reevaluated with the computer model changed to reflect these modifications. This procedure is considered sufficient to yield acceptable results.

The staff finds that the following items need to be addressed by the DCP because they affect the results of the fuel handling building analysis.

(1) The use of the translational and torsional response of the auxiliary building as input to the base of the fuel handling building must be documented more completely in the Phase I report. Parametric studies to demonstrate the validity of the DCP approach should be included in the report.

(2) The total number of degrees of freedom contained in the dynamic models was reduced to 20-30 degrees of freedom before the dynamic analyses were performed. Some recent studies have indicated that this dynamic reduction often results in serious errors particularly with regard to member loads. The particular set of dynamic degrees of freedom selected for the models should be justified.

3.2.5.5 Conclusion

The staff concludes that the investigations by the IDVP were sufficient to identify areas of concern about the structure qualification and produce satisfactory results thus far, except for the omission of an allowance for accidental eccentricity. DCP should show by parametric studies whether the input of the auxiliary building floor slab motions at el 140 ft can be applied to the fuel handling building model if accidental torsion is omitted. The IDVP should evaluate the results. The use of a degree-of-freedom reduction procedure may not be appropriate and may lead to erroneous member forces in the structure. It should be shown by the DCP and evaluated by the IDVP that the use of this reduction method yields correct results.

3.2.6 Intake Structure

3.2.6.1 Introduction

The intake structure is a seismic Class II reinforced concrete structure which houses the seismic Class I auxiliary salt water (ASW) pumps. Because it houses Class I equipment, the Class II structure must retain its integrity during a seismic event so that the function of the Class I equipment will not be impaired.

The plan dimensions of the intake structure are approximately 240 ft in the north-south direction, parallel to the seaward face of the structure, and 100 ft in the east-west direction. The structure is backfilled on three sides and open to the water on the fourth. The top deck of the structure is at el -31.5 ft. Two ASW pump room concrete ventilation towers and coaxial pipes (snorkels) extend from the top deck to el 49.4 ft. The snorkel pipes provide ventilation to the ASW pump compartment. The top deck is an 18-in.-thick slab, with openings provided for equipment removal. The pump deck floor is at el -2.1 ft and supports the four main circulating water pumps and the four ASW pumps. The ASW pumps are located in the ventilated watertight compartments.

The primary sources of the data used by the staff in its evaluation of the verification of the intake structure are

(1) IDVP Diablo Canyon Nuclear Power Plant - Unit 1 Final Report

(2) Pacific Gas and Electric Company Phase I Final Report Design Verification Program

(3) technical interchange meetings between the IDVP and PG&E as documented in the staff trip reports

(4) review of detailed DCP engineering calculations of the ventilation structure modifications

The soil properties investigations relating to the intake structure are discussed in Section 3.5.

3.2.6.2 IDVP Effort

The IDVP verification consisted of field inspections to ensure conformance between design drawings and as-built conditions and review of the PG&E original design calculations for the DE, DDE, and Hosgri events. The IDVP did not perform separate analyses such as generation of dynamic models and computation of individual member stresses.

The specific samples chosen by the IDVP for review represent approximately one-third of the DCP qualification analysis and were:

(1) The Hosgri and DE mathematical models. This included generation of response spectra and member loads. The DE model was also used to determine the DDE response spectra.

(2) Member evaluation for the beams, columns, walls and slabs. Structural stability was also reviewed with respect to sliding, overturning and soil bearing pressure.

(3) The ventilation structure and snorkels that are part of the ASW seismic Class I system.

During the initial review three EOIs were issued by the IDVP which applied to the intake structure. EOI 1022 was error class A/B and two were not classified. All three were combined into EOI 1022, which is still open. The EOIs applied to as-built configuration of the crane, discrepancies between the Hosgri report and the Blume May 1979 report, and the use of inappropriate floor response spectra for the ASW pump seismic input. The IDVP considers its verification complete and found the DCP work acceptable. Specifically, the IDVP has found the following acceptable:

(1) Qualification analyses reflected the as-built conditions.

(2) Criteria were properly applied. The 10% amplification of horizontal response to account for accidental eccentricity was conservative with respect to floor response spectra. It was not conservative with respect to certain structural members; however, the capacity of these members was sufficient to satisfy properly amplified demands.

(3) Use of the fixed-base model for the DE, DDE, and Hosgri events is acceptable.

(4) The dynamic models used were satisfactory.

(5) The response spectra generated were satisfactory.

(6) Structural members including walls and slabs were qualified for the Hosgri event.

(7) The flow straighteners possessed adequate strength using the ductility criteria specified. Walls and slabs were qualified without the use of ductility considerations.

(8) Vent shaft system was adequate.

The IDVP will report the results of its review of the DCP corrective actions in a future ITR. On the basis of the above IDVP statements, arrived at by reviewing the DCP qualification analyses, the IDVP considers the intake structure to be qualified and to meet licensing requirements. However, the sliding, overturning, and soil bearing pressure calculations are still under review. The soil review is addressed in Section 3.5.

3.2.6.3 DCP Effort

In order to address some NRC concerns not related to the design verification effort about wave forces from a degraded breakwater, PG&E constructed a three-dimensional physical scale model of the cooling water intake basin, intake structure, and a hypothetically damaged breakwater to examine the effects of these wave forces on the structure and its operation. As a result of these scale models tests, it became necessary to modify the ventilation system for the auxiliary salt water (ASW) pumps to prevent ingestion of water into the pump chambers. No significant slam pressures were noted from these tests on either the curtain wall or the floor of the pump compartment, provided that the top deck slab was modified. The slab was modified by providing a nonstructural fillet between the front curtain wall and the underside of the top slab and modifying the forebay access manhole to prevent air inleakage. These modifications will be verified by the IDVP. The DCP also performed the following investigations:

(1) It verified that the spectra generated for the DE, DDE, and Hosgri events were adequate for the design of the seismic Class I ASW equipment.

(2) It verified that a gantry crane failure would not impair the seismic Class I ASW systems.

For the seismic studies, two types of analyses were performed to evaluate the structural response of the intake structure. These were a time-history linear analysis to obtain support point response spectra for the ASW equipment and a modal analysis of the structure to determine the structural responses to the earthquake.

The gantry crane analysis used the as-built drawings as the basis to generate the seismic methematical model. The analysis considered the crane in the operating position for both the loaded and unloaded cases. The crane could not affect the ASW pump systems in the parked position. The analysis showed the crane was stable and the members and joint stresses were within allowable limits.

3.2.6.4 Staff Evaluation

IDVP Effort

The IDVP review consisted of field verification of the as-built structural configuration against the design drawings, a review of the PG&E original calculations, and a review of the DCP verification calculations of the ventilation modifications. The initial review by the IDVP revealed the inappropriate use of the floor response spectra for the input motion of the ASW pumps. The subsequent review of the DCP evaluation showed the response at the ASW pumps had been correctly determined.

The staff finds the IDVP review adequate to determine the acceptability of the DCP evaluation. The conclusion is based on the material presented in the IDVP Final Report and reinforced by the staff review of the DCP ASW pump ventilation structure modification calculations. The question of the sliding, overturning and soil bearing properties is addressed in Section 3.5.

DCP Effort

The DCP evaluation consisted of a review of the seismic models used for the Hosgri evaluation, modified as necessary to reflect the as-built configuration, and the modifications to the ASW pump chambers ventilation system. New response spectra for the ASW pump support were calculated and an evaluation of the structure was performed. The assessments of the structural stability against sliding, overturning, and foundation bearing capacity are addressed in Section 3.5.

The staff finds the DCP evaluation of the structural portion of the intake structure acceptable. This conclusion is based on the findings of the IDVP, a review of the material presented in the PG&E Design Verification Program Phase I Final Report, and an audit of the ventilation structure calculations.

3.2.6.5 Conclusion

Based on the material presented in the final reports of both the IDVP and the DCP and the staff audit of the DCP calculations of the modifications to the ASW pump chambers ventilation structure, the staff finds the structural evaluation of the intake structure acceptable. The questions concerning the sliding, overturning, and soil bearing pressures are addressed in Section 3.5.

3.2.7 Outdoor Water Storage Tanks

3.2.7.1 Introduction

The outdoor water storage tanks (OWSTs) are of four types: (1) the refueling water storage tank, (2) firewater/transfer storage tank, (3) condensate tank, and (4) primary water storage tank. The tanks are located outside the fuel handling building. Except for the firewater/transfer tank, there are two tanks of each type, one to service each unit of the plant. Only one firewater/transfer tank is provided. The tanks are made of a steel dome top and a steel cylinder, which is anchored to a concrete base. The steel shell and dome have been covered with a reinforced concrete shell. The concrete shell provides protection against the external hazards such as tornado missiles. The firewater/transfer tank is constructed in the same way, except it is a coaxial tank with the inner cylindrical tank being the firewater tank and the outer portion being the transfer tank. The inner and outer steel cylinders are connected by a common steel dome roof. All of the tanks are supported on concrete fill down to bedrock and are anchored to the foundation with rock anchors.

The primary sources of the data used by the staff in its evaluation are

(1) IDVP evaluation as documented in ITR 16

(2) IDVP Diablo Canyon Nuclear Power Plant - Unit 1 Final Report

(3) Pacific Gas and Electric Company Phase I Final Report Design Verification Program

(4) technical interchange meetings between the IDVP and PG&E as documented in the staff trip reports

3.2.7.2 IDVP Effort

The IDVP verification of the outdoor storage tanks consisted of selecting one of the tanks verified by the DCP and reviewing this analysis work. The tank selected was the refueling water storage tank, a seismic Class I component. The IDVP examined the DCP qualification analyses for all seismic and nonseismic loads. The seismic loads are the DE, DDE, and Hosgri events and the associated fluid dynamic forces. The nonseismic loads are pipe reaction and hydrostatic and dead loads.

The IDVP design review included assessments of the completeness, applicability, and consistency of the DCP review and reanalysis methodology. During the IDVP review hand calculations were performed, where necessary, to assess the effect of various DCP assumptions and calculations. Conformance with the licensing criteria, the accuracy of calculations, and the qualification process were also assessed. The refueling tank was chosen as the sample tank because it contained modifications for the Hosgri evaluation. Topics reviewed were

(1) conformance of analyses to as-built condition
(2) formulation of dynamic models
(3) consideration of fluid forces under seismic excitation
(4) structural stability - sliding, overturning, and soil bearing pressure

The verification program conducted by the IDVP is considered complete, and the conclusions the IDVP reached are:

(1) The qualification analysis was found to be acceptable.

(2) The dynamic analyses and results are acceptable.

(3) Sliding, overturning, and soil bearing pressure factors of safety are acceptable.

As a result of the preliminary investigations by Robert L. Cloud and Associates (RLCA), two EOIs were issued. The subject of these EOIs was the transmittal of design information between PG&E and URS/Blume, the subcontractor that performed the analysis. The DCP verification of the outdoor water storage tanks and its review by the IDVP satisfactorily resolved these EOIs. The IDVP concluded that the outdoor water storage tanks are qualified and meet the licensing requirements.

3.2.7.3 DCP Effort

The DCP verification consisted of performing independent hand calculations for the refueling water storage tank only for the Hosgri event. The results of the hand calculations were compared to the original finite-element analysis for the tanks described in the Hosgri report. Minor discrepancies were identified between the as-built structural configuration and the original seismic finite-element analysis. Calculations were performed and the results were compared to the original analysis to assess the significance the differences these variations made on the final results. The effects were minimal and the computed stresses were less than the allowable limits. The tanks were also reviewed for the DE and DDE by performing hand calculations using the original Hosgri finite-element analysis as a basis. The computed stresses were less than the allowable limits. The factor of safety against overturning and sliding for the foundation was computed by the DCP as 1.60. The uplift on the rock anchors was within the allowable capacity of the anchors.

3.2.7.4 Staff Evaluation

<u>IDVP Effort</u>

The IDVP evaluation consisted of reviewing the work of the DCP and performing hand calculations where necessary to assess the effects of various DCP assumptions and calculations. The DCP work reviewed was the comparison of the analyses to as-built conditions, formulation of dynamic models, method of fluid force consideration, and structural stability. The IDVP found the DCP analyses acceptable. The two EOIs issued by RLCA as a result of the work performed before the DCP evaluation were closed. These EOIs related to the use of correct design information for the Hosgri evaluation.

The staff agrees with the results of the IDVP structural evaluation of the tanks. However, the questions about soil properties raised by the staff in the review of ITR 16 have not been resolved. These items are discussed in Section 3.5.

DCP Effort

The DCP evaluation consisted of a review of the original analysis for the refueling water storage tank and a limited analysis of the firewater and transfer tank vault opening area. The validity of the original finite-element analysis was confirmed using hand calculations and comparing the results to the original analysis. The comparison shows that the hand calculations produced sometimes higher forces and sometimes lower forces. However, the forces predicted by either method were less than the capacity of the tank at the particular section being investigated. Some minor discrepancies were identified between the as-built structural configuration and the original seismic finite-element model but were shown to be of minor consequence.

The staff finds the DCP evaluation to be of good quality and one that would lead to valid conclusions. The staff finds the DCP analysis acceptable.

3.2.7.5 Conclusion

Based on the information presented in the final reports of both the IDVP and PG&E, the staff concludes that the outdoor water storage tanks are acceptable and meet the licensing requirements, except for the questions about the soil properties that are addressed in Section 3.5.

3.2.8 Turbine Building

3.2.8.1 Introduction

The turbine building is a seismic Class II structure containing seismic Class I equipment. In accordance with the FSAR, a seismic Class II structure is required to retain its integrity during a seismic event so that the function of Class I equipment will not be impaired.

The turbine building is a combined steel frame and concrete structure with lateral force resistance provided by a combination of vertical cross-bracing and reinforced concrete walls. The reinforced concrete structure is below the operations level floor (el 140 ft) and the steel frame structure is above the operations level floor. The structure is founded on the underling bed rock. The Unit 1 turbine building is contiguous to the Unit 2 turbine building. The Unit 1 turbine building is rectangular in shape and is approximately 400 ft long in the north-south direction, 140 ft wide in the east-west direction; and approximately 125 ft high. The turbine building has four working floors located at elevations 140, 119, 104 and 85 ft. The reinforced concrete turbine pedestal, which supports the turbine generator, is located in the center of the building and is structurally independent of the building structure. An overhead crane that serves the entire facility is located at el 180 ft.

The primary sources of data used by the staff in its elevation of the verification of the turbine building

(1) IDVP Diablo Canyon Nuclear Power Plant - Unit 1 Final Report

(2) Pacific Gas and Electric Company Phase I Final Report Design Verification Program

(3) technical interchange meetings between the IDVP and PG&E as documented in staff trip reports

3.2.8.2 IDVP Effort

The IDVP verification consisted of examining the DCP qualification analyses for all seismic and nonseismic loads. The seismic loads are the DE, DDE, and Hosgri events; the nonseismic loads are dead and live loads. The IDVP verified, on a sampling basis, DCP dynamic analysis, member qualification, and response spectra generation for accuracy and conformance to licensing criteria. The results of this verification will be presented in a future ITR.

The DCP has evaluated the structural integrity of the turbine building for the postulated Hosgri event, but floor response spectra used for evaluation of safety-related equipment have been computed for DE, DDE, and Hosgri conditions. Safety-related equipment in the turbine building consists primarily of the emergency diesel generators, switchgear, component cooling water heat exchangers, and associated piping.

For the turbine building the DCP reviewed the as-built drawings and made modifications to the analysis as necessary. The DCP developed new dynamic models and performed reanalyses for member evaluation, generation of response spectra, and crane and pedestal qualification. The DCP is currently reanalyzing the area near the switchgear at el 119 ft. This reanalysis is expected to lead to physical modifications intended to stiffen the structure, thereby reducing response spectra at this floor.

The IDVP selected a sample of DCP qualification analyses and reviewed it in detail. A design review checklist was used by the IDVP to ensure that critical items concerning criteria, methodology, and results were adequately reviewed and documented. The IDVP verification included an assessment of the completeness, applicability, and consistency of the DCP and reanalysis methodology. The sample DCP files selected by the IDVP for review were:

(1) Methodology and procedures used in the formulation of mass properties at 140 ft

(2) Computation of stiffness properties for the Hosgri horizontal models. This included review of the various DCP models for both response spectra generation and member evaluation.

(3) DCP procedures and calculations for determining equivalent beam properties used in the dynamic models

(4) Methodology and calculational procedures for one of the four vertical dynamic models, including review of boundary conditions at adjacent vertical modes

(5) Generation of response spectra at required locations from the Hosgri horizontal and vertical models

(6) The turbine pedestal/operating deck relative horizontal motions

(7) Calculation of stresses and comparison with allowable values according to licensing criteria for a sample of structural members

The IDVP did not include the turbine building crane in the samples. The IDVP-selected samples consisted of approximately 30% of the DCP qualification analysis files for the turbine building. Alternate calculations were performed by the IDVP, where necessary, to assess the effect of various DCP assumptions and calculations. For the turbine building, the IDVP performed no separate analyses of the dynamic models. No EOIs have been issued regarding corrective action.

Although the IDVP had not completed its verification program on the turbine building, the work was sufficient to consider that the following portions of the DCP evaluation were acceptable and satisfied the licensing criteria:

(1) qualification analyses properly reflecting the as-built design drawings
(2) mass properties used in the computer models
(3) bolt-bearing and connection capacities for the roof chords

The IDVP considered the following aspects of the DCP work to be unresolved issues:

(1) the capacities of certain cross-braced exterior panel
(2) modifications planned by the DCP to stiffen the floor at el 119 ft

3.2.8.3 DCP Effort

The DCP confirmed or developed a basis for the seismic Class I equipment qualification for the DE, DDE, and Hosgri events. The turbine building, turbine pedestal, and turbine building crane structures were reviewed for the Hosgri event to ensure that these structures would not fail and impair the function of the seismic Class I equipment located inside the building.

The seismic analysis and design of the turbine building, including the turbine pedestal and turbine building crane, were reviewed to determine that the as-built condition was adequately represented, and that appropriate seismic criteria and analytical methods were used. As a result of this review, the turbine building, pedestal, and crane analytical models were revised, as necessary, to adequately represent the as-built condition. The resulting models were used for the building structural design review and for confirmation or development of floor response spectra. One horizontal seismic model was used to represent the building in the north-south and east-west direction; four models were used to represent the building in the vertical direction.

The horizontal model was primarily composed of equivalent beam elements for most of the structural members. The exceptions were plane stress elements for concrete walls and some of the floor diaphragms, and truss elements for diagonal bracings. The roof truss and lower bracings were models using equivalent members (generalized uniaxial elements) to reduce the size of the model. The equivalent masses of the crane and trolley were obtained by using the limiting magnitude of the bracing forces and were lumped symmetrically about column line 9 (located approximately at the middle of the building). Damping used in the models was 7% for the Hosgri event and 5% and 2% for the DE and DDE events for concrete and bolted steel. This horizontal model was fixed at the base and had a total of 396 nodes, 438 beam elements, 183 truss elements, and 30 generalized uniaxial elements.

Blume and Newmark Hosgri horizontal motions were considered for the evaluation of the member forces, while additional DE and DDE motions were considered for generating the floor response spectra. All member forces were found to be satisfactory as shown in summary tables (2.1.4-13-16) of the DCP report.

The seismic analysis in the vertical direction used four new models representing different areas of the building to analyze the structure subject to Newmark Hosgri vertical motions. Areas represented were those between column lines 1 and 5, 5 and 15, 15 and 17, and 17 and 19. According to the DCP, the basis for choosing four vertical models to analyze the turbine building for the vertical component of ground motion was that the large openings in the floors at the turbine pedestal divides the floors into separate areas. Because the Newmark Hosgri vertical motions envelop those from the Blume motion, the Newmark Hosgri motion was the only input used for the vertical analysis.

The response of the turbine building crane was analyzed in the following manner. The crane is stiff in the east-west direction and will not amplify the east-west motion input to the crane from the the turbine building. However, the crane is flexible in the north-south direction and vertical direction, and two separate models have been developed to calculate these responses.

The north-south model consists of prismatic beam elements for the bridge girders and end tie beams. The unloaded trolley was considered to be at center span and was modeled accordingly. The input motion was the appropriate turbine building floor response spectra. The vertical motion was the appropriate turbine building floor response spectra. The vertical motion includes three building frames and the runway girders extending to the midspans beyond the end frames. The crane bridge and trolley were modeled similar to the crane north-south model. Only the Newmark Hosgri vertical motion was used.

The original 3-D model of the turbine pedestal was found adequate; thus, it was used for the new analysis. Blume and Newmark Hosgri horizontal motions were considered for the evaluation of the horizontal model, while only the Newmark Hosgri vertical motion was used for the vertical model.

The results of the analysis indicated that the strength of the pedestal members was adequate. Although the dynamic response showed that the separation between the pedestal and the turbine building was adequate, the DCP recommended removing the upper 2-5/8 in. of neoprene.

During a meeting held on April 6 and 7, 1983, where an inspection of the technical calculations in support of the DCP program was made by the staff, concern was expressed with respect to overstress found in eight bolted joints which occurred in gusset plates that tie some bracing members into the roof grid. The overstress was based on criteria given in AISC Edition 7 and Edition 8. At the meeting the DCP stated that when ductility is accounted for (as allowed in the criteria), the joints could be shown to be capable of withstanding the loads.

Modifications to the structure were made to reduce the horizontal and vertical building response spectral accelerations in the region of the 4160-V switchgear at el 119 ft. To reduce the vertical accelerations in the switchgear area, the top and bottom connections of a total of six existing columns on lines 3 and 4 were modified to allow the floor at el 119 ft to act together with the floor at el 140 ft. In addition, a new column was provided along line 4. To reduce the horizontal spectral accelerations, five existing beams along lines A and G at 119 ft were stiffened, three interior beam connections were modified at el 104 and 119 ft, a new beam was added along line E at el 119 ft between lines 3.5 and 4.8, and diagonal bracing was added along line A between el 104 and 119 ft and column lines 4.8 and 5.7. A 2-in. steel plate was added along line G between el 104 and 119 ft and lines 3.5 and 4.8, and modifications of associated checkered plate welding and connections to the concrete walls were made. Additional modifications included the increase in area of the beams at el 119 ft on line G from line 15 to 18. The modifications described were included in the seismic models.

3.2.8.4 Staff Evaluation

<u>IDVP Effort</u>

The IDVP verification of the DCP analysis of the turbine building consisted of sampling the DCP analysis. THE IDVP verification is not complete and will be reported in a future ITR.

On the basis of the information provided to the staff by the IDVP in the IDVP Final Report, the program should lead to verification of the DCP evaluation if correctly implemented. The staff will fully evaluate the IDVP verification when a future ITR on the subject has been issued.

<u>DCP Effort</u>

The DCP review consisted of reviewing the design drawings and determining the as-built condition of the turbine building. The as-built condition was used in determining the parameters for the seismic models. The models used to produce floor response spectra and determine member forces reasonably describe the structure and should produce reasonably accurate results if correctly carried out. The analysis effort by the DCP pointed out a few deficiencies, and modifications were made.

The staff finds that information is needed with regard to the following concerns for an evaluation:

(1) Although the design criteria stipulate that the strength requirement for the structural members is based on combined dead, live, and earthquake forces, the summary tables showing the member forces do not indicate clearly such combination. If the member forces are due to earthquake alone, then a discrepancy exists.

(2) The method of modeling the roof truss by two generalized uniaxial members and obtaining individual truss member responses from the uniaxial member model is questionable, since the action of the member is different from

that of a truss and the maximum response of the model may not be the maximum response of each individual truss member.

(3) The reason for using four separate vertical models for the turbine building is based on the fact that the large openings in the floors at the turbine pedestal divide the floors into separate areas. However, the effect of the continuous exterior wall that connects to all the floors was not investigated. This could effect the final results.

(4) The differences in modeling the steel frame and roof truss for vertical model 1 and vertical model 2 need clarification. Specifically, the reason for changing the roof truss, modeled as a truss in model 1, to uniaxial members in model 2. Furthermore, a basis should be provided for why the nodes above 140 ft have 6 degrees of freedom for model 1, while they only have 3 degrees of freedom for model 2.

(5) The statement in the PG&E Phase I Final Report, "Alternative procedures are being reviewed to assure that the model combination by SRSS is acceptable," needs to be explained as to what alternative procedures were used.

(6) The statement in the PG&E Phase I Final Report, "Co-directional response due to the three orthogonal components of ground motion are combined on an SRSS basis, or equivalent," indicates some other material or component combination was used. The equivalent method needs to be explained.

(7) The use of the AISC Code 8th Edition is in violation of the acceptance criteria delineated in the FSAR. The use of the increased allowable stresses should be justified.

3.2.8.5 Conclusion

The staff concludes that the verification plan of the IDVP should lead to establishing the acceptability of the turbine building. However, the final conclusion will be based on the staff review of the future ITR on this subject. The items listed in the staff's evaluation above should be addressed by the IDVP.

3.3 Piping and Piping Supports

3.3.1 Large-Bore Piping and Supports

3.3.1.1 DCP Effort

Large-Bore Piping

The Diablo Canyon Project (DCP) reviewed all seismic Class I large-diameter piping, except for that analyzed by Westinghouse. Large-diameter piping is defined as that having a diameter of 2-1/2 in. or greater. Piping previously analyzed by Westinghouse, which includes the reactor coolant loop piping, was not reanalyzed by Westinghouse unless there was a revision in input data.

The reanalysis of all large-bore piping was performed subject to the criteria described in Sections 3.7 and 3.9 of the Diablo Canyon FSAR and Section 8 of the Hosgri report. These criteria were not changed for the purposes of this reanalysis. For seismic Class I piping the load combinations and allowable stresses were used with the applicable piping code, ANSI B31.1-1973 Summer Addenda.

The DCP evaluated pipe stresses resulting from pressure, deadweight, thermal, DE, DDE, and Hosgri events. For evaluation of the stresses resulting from the Hosgri event, the load combination consisted of pressure, deadweight, and Hosgri seismic loading. Where applicable, hydrodynamic loading has also been included in the analysis.

Seismic dynamic analyses were performed by the response spectrum modal superposition method, as described in the FSAR. This method uses enveloped horizontal and vertical acceleration building spectra to develop the model loading. Two separate analyses were performed for a given piping structure, consisting of the spectra in the vertical direction and each horizontal direction. The loads from both analyses were then enveloped and introduced into the code stress and compared to the applicable stress criterion. Seismic anchor motion resulting from differential building motion or flexible equipment motion was not included in the Hosgri reevaluation, per Hosgri criteria, but was considered for the DE event only.

All lines were also reviewed to confirm that the thermal analysis considered the modes of operation defined in the applicable Diablo Canyon Design Criteria memorandum. Thermal loads were also combined with sustained loads and DE seismic anchor levels to evaluate the resulting stresses according to ANSI B31.1.

For the static and dynamic analysis the piping was reevaluated using as-built configurations as input. These configurations were determined by an onsite walkdown and recording of data, such as type and location of supports on the relevant isometric drawings. These drawings were used to develop the models used in the computer analyses. For the seismic analyses the relevant Blume and Newmark spectra were enveloped. However, the PG&E Phase I Final Report does not indicate which spectra are being used in the seismic review of a number of buildings that is still ongoing.

The PG&E piping reanalysis was done using the Bechtel computer program ME101. The Westinghouse reanalysis was done using the program WESTDYN. Both programs were accepted by the NRC because of their capability to perform seismic analysis using envelope spectrum modal superposition analysis. The output of the piping analyses included pipe stresses, support loads, equipment loads, and valve accelerations.

Large-Bore-Piping Supports

Supports for safety-related large-bore piping were reviewed by the DCP and modified, if necessary, to ensure compliance with the previously accepted criteria listed in the Hosgri report. This included a review of the design, methodology, and documentation. New supports that were added to maintain piping stresses within the piping allowable limits were also designed to satisfy the same criteria as the existing supports. All supports were required to be designed with a natural frequency of at least 20 Hz in the restrained direction.

Loads resulting from thermal, dead-load hydraulic loads and seismic loading were used to review pipe supports. For the Hosgri analysis the load combination consisted of dead load plus Hosgri inertia and anchor movement loads. For concrete expansion anchors this combination was augmented by loads resulting from restrained thermal expansion. For load combinations including DE and DDE, the load combinations included dead load, hydraulic loads (resulting from fast valve closure or relief valve thrust), and loads resulting from restrained thermal expansion and differential seismic anchor movement.

Depending on the code interface boundary, either ANSI B31.1 or AISC criteria were used as stress and load criteria, previously specified and accepted in the Hosgri report. For qualification of supports by testing, the ASME Code, Subsection NF rules for qualification by testing were used where appropriate. For standard component supports, such as snubbers, springs, and rods, the load capacity data sheets or manufacturers' recommended values were used for allowable loads. For concrete expansion anchors, the allowable loads are those that were developed to comply with the requirements of NRC Office of Inspection and Enforcement Bulletin 79-02.

Results of Reanalysis

The results of the DCP piping review and reanalysis are shown in two extensive tables in the PG&E Phase I Final Report (Tables 2.3.1-1 and 2.3.1-2). For each piping system the review consisted of the following:

(1) Maximum stress ratio-maximum actual stress divided by the allowable stress

(2) Allowable stress corresponding to the load case with the maximum stress ratio

(3) Load case with the highest stress ratio

(4) Pipe modification, such as rerouting

(5) Number of pipe supports

(6) Number of support modifications

(7) Building or structure in/on which the piping is located. The containment annulus structure was considered as a part of containment and was not listed separately. The fuel handling building was included as a part of the auxiliary building.

In some cases the piping stress analyses were based on preliminary input such as spectra and building displacements, as stated above. PG&E has indicated that controls are in place to ensure reconcilation of these analyses and resultant designs with the final input data. These cases are not listed in the tables.

Piping and supports required for fuel loading are summarized in Table 2.2.1-3 in the PG&E Phase I Final Report. A total of 88 piping analyses, or problems, were performed. Of these 54 were in the auxiliary/turbine building, 33 in the containment building, and 1 in the yard. All stress ratios were less than 1, i.e., below the allowable limit. In most of the analyses the thermal load condition caused the maximum stress ratio. This was probably a result of the additional stiffening of the piping system which was added to withstand the seismic loading. A total of six pipe modifications consisted mostly of rerouting or adding reinforcing pads at branch connection points. Of the 2253 supports in these piping analyses, 1473 were added or modified in some manner. The most frequent type of modification consisted of the addition of a support or a change in support type. Other types of modification consisted of additions of bracing members, changes in structural shape, or other minor changes. No breakdown is shown in the table by type of modification, nor is the stress or load ratio for the highest loaded support reported.

Piping and supports not required for fuel loading are listed in Table 2.2.1-4 of the PG&E Phase I Final Report. A total of 171 analyses were performed; of these 69 were in the containment building. Again, in most of the analyses the thermal load condition caused the maximum stress ratio; all stress ratios were again calculated as less than 1. There were 10 pipe modifications consisting mainly of rerouting. Of the 2303 supports, 1410 were modified in some manner.

3.3.1.2 IDVP Effort

Initial Effort

The IDVP performed an analysis and review of an initial sample of large-bore piping. This analysis was performed by Robert L. Cloud and Associates (RLCA) and reported in ITR 12.

The initial sample consisted of 10 piping models that were taken from various plant safety-related systems. To obtain a representative sample RLCA reviewed Table 8.3 of the Hosgri report. As a result of the general plant walkdown and drawing reviews, the 10 initial piping samples were chosen, considering the location, system, class, intersystem connections, types of valves, and groups that performed the design analysis. The RLCA effort for the initial sample consisted of the following major tasks:

(1) field verification and comparison to design isometrics

(2) development of a computer model of each model and an independent Hosgri seismic analysis

(3) comparison of results to the stress or load criteria and to the results of the design analysis

(4) followup analysis to reconcile differences, where possible, between the independent verification analyses and the design analyses

RLCA field-verified each sample problem, starting with the design drawings prepared in response to NRC IE Bulletin 79-14. The information that was verified included pipe size, location, concentrated weights (valves, flanges, etc.), insulation, vent/drain lines, valves (e.g., operator orientation), supports (location, type, orientation), and connected equipment.

Based on the design isometrics and the field-verification results, RLCA developed a computer program piping model for each sample. Particular consideration was given to modeling boundary conditions and intermediate supports (e.g., whether terminal equipment was rigid or flexible, supports were active or inactive (large gaps or one-way supports)), and modeling concentrated masses, including centers of gravity of such components as remotely operated valves. Once the model geometry and piping properties were formulated, seismic and deadweight loads were defined for each piping sample. The seismic analysis consisted of the following:

(1) Hosgri response acceleration spectra were assembled based on pipe size and attachment locations.

(2) The damping ratios used were 3% for piping with a nominal diameter greater than 12 in. and 2% for piping with a nominal diameter less than or equal to 12 in.

(3) The dynamic analysis was performed by the envelope response spectrum method using the NRC-verified computer program ADLPIPE.

(4) Two separate analyses were performed in which the dynamic response for each analysis was calculated based on one horizontal plus one vertical input spectra. The response on a modal level from each direction was added by absolute sum. All modal responses were then combined by the square root of the sum of the squares to obtain the final 2-D response. The total response was enveloped from the two separate analyses, one with north-south horizontal and vertical spectra, the other with east-west horizontal and vertical spectra.

(5) The dynamic response considered the greater of either 10 modes or all modes less than 33 Hz, the rigid cutoff frequency.

In addition to seismic loads, sustained loads consisting of deadweight and pressure loadings were also evaluated and combined with seismic loads.

RLCA compared the results of their independent analyses to both the Hosgri licensing criteria allowable limits and to the design analysis results. The Hosgri criteria for piping are based on Equation 12 of ANSI B31.1b-1973. For the comparison of the verification analyses and the design analyses (based on the cited equation) of Hosgri stress, RLCA selected the five locations of highest combined stresses or locations where the combined stress exceeded 70% of the allowable limit. A comparison of pipe support loads, nozzle loads, and valve accelerations for the verification and design analyses was also performed.

If, in comparing the verification and design analyses, the seismic stress or seismic support load results exceeded the 15% acceptance criteria, RLCA examined the differences through additional analyses. The followup analyses consisted of making the verification model more and more identical to the design model until seismic stresses, loads, and accelerations met or approached the 15% criteria, or until the differences could be explained.

The initial sample effort on large-bore piping led to the issuance of 73 EOIs. These were resolved as follows (definitions are given in Section 1):

Findings	7
Combined with findings	7
Observations	41
Closed items	18

Based on these resolutions, RLCA identified eight generic concerns:

(1) In several cases, the PG&E 79-14 design isometrics do not completely reflect the as-built conditions. As a result, the design analyses differed from the as-built piping configurations.

(2) In several cases, the documentation and modeling of remotely operated valves did not reflect the as-built conditions.

(3) In several cases, the modeling of attached equipment as in-line components or as terminal points did not adequately consider equipment flexibilities and support conditions.

(4) In several cases, the design analysis response spectra did not envelope the Hosgri response spectra. In addition, Hosgri response spectra were not identified for several plant locations/elevations from which seismic Class I piping is supported.

(5) In certain cases, the tributary pipe mass assigned to support locations in the design analyses was not considered in calculating support loads.

(6) In several cases, pipe and component (e.g., flanges) weights in the design analyses differed from the vendor-supplied values.

(7) In several cases, the design analyses did not consider branch lines and analysis overlap with adjacent systems in an adequate manner.

(8) In several cases, the valve accelerations and equipment nozzle loads exceeded their respective allowable values.

In addition to the eight generic concerns, one RLCA concern related to the modeling of standard fittings, such as swage fittings and tees. In several cases, equivalent pipe properties were not used.

Based on the findings in this initial piping sample, the DCP initiated a plan for corrective action for computer-analyzed piping which included a complete walkdown and a review of all design analyses. Deficiencies were to be corrected by additional qualification and verification. The IDVP for the PG&E corrective action, which is described below, was initiated to provide assurance that the above concerns have been addressed.

Additional Effort

After the initial sample was analyzed and reviewed, RLCA reviewed an additional sample of five more models as specified in ITR 1. These models were selected from piping categories not represented in the initial sample. The additional models were selected to determine if all concerns with computer-analyzed piping were identified for inclusion in the DCP Corrective Action Program.

ITR 17 reported the RLCA review of the IDVP additional sample for large-bore piping. The additional sample of five piping analyses was selected considering the following categories of piping not included in the initial sample:

(1) piping connected to primary loop piping analyzed by others
(2) computer-analyzed field run piping
(3) seismic Class I subclasses not included in initial sample

RLCA used the same analytical procedures and evaluation criteria for the additional sample as were used for the initial sample except followup analysis was not performed where differences in results could be attributed to significant differences in geometry or analytical modeling. The additional sample of large-bore piping led to four EOIs:

Finding	1
Combined with findings	2
Observation	None
Closed item	1

One of the findings was issued because the RLCA verification analysis showed stresses exceeding the allowable value for small attached vent and drain lines and the existence of two supports which were deadweight supports only (capable of resisting gravity but not two-way seismic motion).

A generic concern was also reported in ITR 17 in that in several cases, the design analysis did not apply the appropriate stress intensification factors in determining pipe stresses, particularly at socket welded connections.

3.3.1.3 IDVP Verification of DCP Corrective Actions

Large-Bore Piping

The IDVP reviewed a new sample of 18 DCP piping analyses chosen from the category of computer-analyzed piping. This sample was chosen on the basis of the definition of the verification of DCP activities in ITRs 8 and 35.

The selected piping samples were chosen to include various combinations of concerns identified in the initial review phase, and to provide assurance that these concerns were incorporated and resolved in the DCP Corrective Action Program.

The IDVP performed its review by examining, through checklists, the DCP calculation packages and computer outputs. Model geometries for 12 of the analyses were field walked to ensure conformance between design drawings and as-built configurations. The checklists were used to verify that critical items concerning criteria, methodology, and results were adequately checked and documented in the IDVP review process. The IDVP review process included assessments of the competeness, applicability, and consistency of the DCP review and analyses. In some cases, the IDVP performed alternate calculations to review the DCP calculations.

As a result of this review four new EOIs were issued as follows: EOI 1126 addresses the stress intensification factor (SIF) discrepancy for intermediate butt welds and the omission of a SIF of 1.9 at valve to elbow interfaces. This item has been incorporated into the DCP final review checklist for review of potential impacts on all DCP analyses. EOIs 1133, 1135, and 1137 address discrepancies in valve modeling and weights. These EOIs have been combined to form a generic concern with valve modeling. This item has also been incorporated into the DCP final review checklist for review of potential impacts on all DCP analyses.

The IDVP evaluation is not yet complete. On the basis of the efforts performed to June 30, 1983, the IDVP considers that the following aspects of the DCP work are acceptable and satisfy the licensing criteria:

(1) The DCP reanalysis of all original work and the development of the DCP final review checklist is an appropriate program for qualification of all DCP analyses.

(2) Overall modeling methods were found acceptable, except for application of SIFs and valve modeling as noted above.

(3) Loadings used in the DCP analyses were found acceptable. Loading data were found properly controlled and applied by the DCP.

(4) Internal documentation was found to be in sufficient detail to allow the verification of transfer of data. Computer files and descriptions were indexed.

(5) Stress analyses were found acceptable for all reviewed analyses except two. These contained unique discrepancies and were reanalyzed by the DCP.

(6) Numerical accuracy of the calculations sampled was adequate.

In summary, the IDVP has concluded that DCP is following established procedures and licensing criteria and is meeting the latest loading criteria and operating modes. The concerns about SIFs and valve modeling were determined to be generic concerns. These generic concerns are being resolved by the inclusion of specific checks in the DCP final review checklist. Certain valve models and SIFs will be reviewed by the IDVP after they have passed the DCP final review. None of the specific concerns that led to these two generic concerns caused an exceedance of the licensing criteria. The DCP Corrective Action Program for seismic Class I large-bore piping adequately covers all essential steps required to obtain proper qualification of the piping.

The IDVP considers the following aspects of the DCP work to be unresolved issues at this time: EOIs 1126, 1133, 1135, and 1137. The IDVP intends to formulate a final conclusion as to the qualification of large-bore piping and its conformance to licensing criteria when the IDVP verification is completed. The complete results will be reported in a future ITR.

Large-Bore Piping Supports

The IDVP review of the DCP Corrective Action Program for large-bore-piping supports is defined in ITRs 8 and 35. The IDVP review consisted of an examination of the qualification of each pipe support for all seismic and nonseismic loads. Seismic loads are the DE, DDE, and Hosgri events; nonseismic loads are dead load, pipe break loads, friction, fast valve closure, and relief valve opening thrust.

The IDVP stated that all seismic Class I large-bore-piping supports were reviewed by the DCP to ensure compliance with design criteria, as contained in the FSAR and Hosgri report.

The IDVP selected a sample of the DCP support design analyses to verify conformance to the DCP criteria and accuracy of calculation. The samples were selected on the basis of the following considerations:

(1) Supports associated with the large-bore-piping sample

(2) Review of the DCP general pipe support status log to determine revision status. This log listed approximately 6000 to 7000 supports.

(3) Representation of various support types, pipe sizes, plant locations, and organizations (consultants) performing design analyses.

The IDVP selected a total of 22 support analyses for review. The support types were snubbers, hangers, anchors, and rigid supports. Design reviews of these analyses were performed to verify the following aspects of the design analysis:

(1) validity and completeness of design inputs
(2) compliance with design procedure and criteria
(3) validity of design assumptions
(4) validity of analysis conclusions

Approximately 70% of the support sample was field-verified to confirm the as-built condition.

The IDVP performed an analysis package and pipe support review to evaluate the completeness of all pertinent design input data, output results, and associated documentation. Alternate calculations were performed, where necessary, to assess the effects of various DCP assumptions and to confirm calculations. As a result of these reviews, three EOIs were issued as discussed below.

EOI 1122 was issued to note that the design analysis for one pipe support does not address support frequencies in the unrestrained direction as required by the DCP criteria. The DCP has revised this analysis to address frequencies in the unrestrained directions. This revision remains to be verified by the IDVP. It is, however, not considered a generic concern because support frequency requirements were not included in the licensing criteria.

EOI 1129 notes that errors were made in calculating the weld stress for weld between pipe lug and supporting steel on a support. This item has been classified as an error Class C. This EOI does not represent a generic concern.

EOI 1131 notes that the design analyses for two supports do not evaluate the shear lugs and attachment welds, as required in the DCP Corrective Action Program. The DCP has revised these analyses to include the shear lugs and attachment welds. The IDVP review of the revised DCP calculations shows these stresses to be small. This EOI has been classified as a deviation.

The IDVP verification effort is not yet complete. On the basis of the efforts performed to June 30, 1983, the IDVP considers that the following aspects of the DCP work are acceptable and satisfy the licensing criteria:

(1) Support drawings are satisfactory.

(2) Pipe support frequencies are satisfactory (except as noted in EOI 1122).

(3) Pipe support stress analyses are satisfactory (except as noted in EOI 1129).

(4) Attachments welded to the pipe are frequently not evaluated in the DCP analysis. Except as noted in EOI 1131, they were found to be satisfactory from IDVP calculations.

(5) Standard component supports such as spring hangers, snubbers, and pipe clamps are satisfactory.

(6) Pipe support analyses were generally performed in accordance with the design procedures.

The IDVP intends to formulate a final conclusion as to the qualification of large-bore-piping supports and their conformance to licensing criteria when all analyses have been evaluated by the IDVP. This activity will be reported in a future ITR.

3.3.1.4 Staff Review and Evaluation

The NRC staff and its consultant, the Brookhaven National Laboratory (BNL), reviewed ITR 12 and ITR 17 and met with RLCA to obtain clarification on a number of topics addressed in this effort and to resolve concerns raised in this review.

The following staff concerns were noted and resolved:

(1) The comparison of support and nozzle loads calculated by RLCA and PG&E showed very large and significant differences. Furthermore, no comparisons with allowable loads or stresses were presented. RLCA stated that the design and analysis of large-bore-piping supports would be reviewed separately as part of the IDVP verification of the DCP Corrective Action Program, and that this concern would be addressed during that review.

(2) The assumption of a heat exchanger as a rigid anchor even though its natural frequency was determined to be lower than the rigid anchor frequency criterion (20 Hz). RLCA indicated that this was done to determine sources of differences between RLCA and PG&E calculations. Heat exchangers were verified separately.

The staff evaluated the analytical and modeling methodology used by RLCA in the verification analyses and concluded that correct and acceptable approaches had been used to determine various inconsistencies and errors in the PG&E designs and analysis of piping and equipment. It also stated that followup efforts will concentrate on verifying that PG&E has correctly addressed the stated concerns.

The IDVP Final Report indicates that the concerns raised in ITRs 12 and 17 are being addressed in this program. The final results of this verification will be reported in future ITRs.

Brookhaven National Laboratory Effort

The BNL performed an independent verification of two PG&E piping systems that are located in the annulus structure. The systems were chosen from the safety injection reactor coolant system (PG&E piping system 6-11) and from the component cooling water supply system to the reactor coolant pumps (PG&E piping system 4A-26) (see also Section 3.6).

The two systems were analyzed under the load combination which included Hosgri magnitude response spectra. The horizontal spectra were taken from the Blume response spectra; the vertical spectra were determined from the BNL evaluation of the modeling and seismic response of the annulus structure.

Two types of seismic analysis were performed. One used the envelope of the response spectra (uniform support motion); the other used the individual support response spectra (independent support motion). Other loadings applied to the systems consisted of pressure, deadweight, and differential seismic anchor movements.

The results for the stresses indicate that for PG&E Piping System 6-11, the calculated stresses were below the specified allowable values except for one point where the stress was insignificantly above the allowable value. For PG&E Piping System 4A-26 all stresses were below the allowable stress value. Support and allowable support loads were not evaluated.

The results of this evaluation indicated that with appropriate response spectra this sample of piping systems satisfies the Hosgri stress criteria, even though these systems were originally designed to different response spectra. Further details on the BNL effort are described in NUREG/CR-2834.

Staff Evaluation

The staff has reviewed and evaluated the submittals from the DCP and the IDVP on large-bore piping and supports. Based on the piping verification effort reported by the IDVP in ITRs 12 and 17, the DCP has reevaluated and reanalyzed all seismic Class I large-bore piping and supports designed by PG&E for Diablo Canyon Unit 1. The results of this reevaluation resulted in a small number of piping changes, but a very substantial number of changes, additions, and modifications of supports.

The IDVP effort determined that in some of the sample analyses, significant differences existed between the PG&E and RLCA calculations for pipe stresses, support loads, nozzle loads, and valve accelerations. The primary causes for these differences appear to be inconsistencies between the design drawings and the as-built geometries, and incorrect specification of building spectra. These include incorrect valve orientations, missing valve supports, or differences in support location. Another cause for stress differences was attributed to incorrect use by PG&E of stress intensification factors.

The results of the DCP reevaluation were summarized in tabular form in the PG&E Phase I Final Report which showed that all reviewed piping systems satisfied the corresponding stress allowable values. However, as stated in Section 3.3.1 the table did not indicate a stress or load comparison for the supports. The staff believes this to be a deficiency in the table. Since all supports were reviewed and qualified for satisfaction of licensing criteria, this information should be available. The staff recommends that as part of the verification of the DCP Corrective Action Program, the IDVP verify and report whether all supports of the reviewed piping satisfy the required allowable loads or stresses, as applicable. In addition, the IDVP should evaluate and justify the buckling criteria specified for linear supports, specifically the rise of the Euler buckling equation for calculating the critica buckling load for all slenderness rates. The staff considers this to be an open issue and will report its resolution in a supplement to the SER.

The results of the reevaluation of piping indicate that the loading combination which caused the highest stress ratios and support modifications was that which included thermal effects. The staff recommends that the IDVP perform an evaluation and verification of a sample of piping where this condition was significant, and that this be reported as part of the IDVP verification of the DCP Corrective Action Program. In view of the significant differences in support and nozzle loads reported in ITRs 12 and 17, the staff recommends that the IDVP repeat the calculations for these piping systems with the present support configuration and the current loading, and verify that the stresses and support satisfy all corresponding design criteria.

The IDVP has also reported the results of its verification of the DCP Corrective Action Program for large-bore piping and supports. Although this effort is as yet incomplete, the staff's review indicates that the IDVP has performed an acceptable review, evaluation, and verification of work performed by the DCP under its Corrective Action Program.

The completed verification by the IDVP of the DCP Corrective Action Program on large-bore piping and supports will be reported in future ITRs. The staff's review and evaluation of these ITRs with respect to large-bore piping and piping supports will be reported in a supplement to the SER.

3.3.2 Small-Bore Piping and Supports

3.3.2.1 DCP Effort

Small-Bore Piping

The PG&E Phase I Final Report states that all seismic Class I small-bore piping was reviewed for compliance with the original design criteria. Small-bore piping was defined by PG&E as that which is less than or equal to 2 in. in diameter nominal pipe size. This piping was designed mostly by the use of spacing criteria and by dynamic analysis.

Two types of reviews were performed: a generic review and a sample review. The generic approach was applied to those analyses or designs for which previous reviews indicated generic issues with a potential for physical modification to maintain compliance with licensing commitments. The sampling approach was applied to those designs where modifications were not anticipated to maintain qualification, and to address design considerations not included in the generic review. For either review, the piping was qualified by span criteria or by computer analysis.

The span criteria used for qualification are described in Section 3.7 of the FSAR and Section 8.0 of the Hosgri report. This methodology was developed to ensure compliance with stress criteria for nonanalyzed piping and supports, and to provide data for qualification of associated equipment. These criteria were also revised to include the effect of insulation weight and spectra revisions.

The methodology for computer analyses, including dynamic and static analyses, was the same as that used for the design of large-bore piping. Piping code stress equations and allowable stress criteria were also the same as those for large-bore piping.

The generic review of all small-bore piping for which dynamic seismic analyses were performed used the same methodology as that outlined for large-bore piping. As-built walkdowns were performed and the dynamic analyses were reviewed to ensure compliance with the criteria. Thermal analyses associated with these seismic analyses were also reviewed.

Each active valve required to bring the plant to safe shutdown following a seismic event was checked to ensure that the accelerations induced by the piping system satisfy vendor allowable values. In addition, inactive remotely operated valves were also checked for accelerations. Where the valve is located within piping qualified by span tables, the valve was rigidly supported.

The boundaries between safety-related and nonsafety-related piping were reviewed for all locations. The objective of this review was to ensure protection of the safety-related side of the boundary. Qualification of these boundaries was obtained by providing either an anchor (equipment, large pipe, pipe support anchor) or two restraints in each lateral direction on the side of the seismic Class II piping and one in the axial direction on either side of the Class I or Class II piping. The supports on the side of the seismic Class II piping were qualified as Class I supports.

Piping designed by spacing criteria, with maximum operating temperatures greater than the spacing criteria method limitations, was identified and qualified to maximum operating temperature conditions. Computer thermal analysis was applied when manual calculation was considered to be inappropriate.

The sample review encompassed 20 pipelines and included a minimum of 5 configurations or conditions for the issues of effect of pipe insulation, revised seismic spectra, concentrated masses, overspans, anchor and equipment loads, pipe as-built configurations, and building and equipment seismic and thermal anchor movement. Computer analysis was used to show qualification if necessary.

A random sample of 13 (approximately 10%) computer thermal analyses on small-bore piping was reviewed to confirm that qualification by existing computer thermal analyses is satisfactory. The same methodology as that outlined for large-bore piping was used.

A summary of the DCP review of all piping previously seismically analyzed by computer and piping previously thermally analyzed by computer with temperatures greater than 165°F or 200°F for carbon and stainless steel, respectively, was presented in tabular form in the PG&E Phase I Final Report. All piping in this category was reanalyzed by computer analysis. The table of results also includes the results of the reviews of piping which were qualified using span criteria.

The summary showed that approximately 1550 piping spans were analyzed. Of these 84% were found to be acceptable as built; less than 2% showed conditions of seismic overstress resulting from the removal of supports to achieve the original thermal qualification; approximately 6% showed an overstress condition resulting from a lack of flexibility in accommodating thermal movements and equipment anchor movement; 8% showed conditions requiring support modifications resulting from the generic qualification of code boundaries and valves. Certain calculations were based on information that requires confirmation and may cause the calculations to be revised.

The review of all valves requiring seismic qualification resulted in 19 support modifications. The generic review of piping affected by seismic and thermal anchor movements of attached large-bore piping was carried out by conducting worst-case analyses. No piping modifications were found to be necessary; however, support modifications were required to facilitate thermal anchor movements. All hot piping was analyzed by computer which ensures resolution of this issue on a generic basis. No support modifications were required for seismic anchor movement considerations.

Piping where seismic Class I/Class II interfaces occur was reanalyzed by computer or span criteria. The review indicated that no piping modifications were required.

The results of the review of all hot piping, which was initially designed by spacing criteria, indicate that support modifications were required to obtain qualification of piping in this category. As a result, the sample approach was abandoned. All piping problems in this category were reanalyzed. All piping in the sample review was shown to be qualified as built. However, three analysis considerations addressed by the sample review were found by other reviews to require an expanded review. The three areas are seismic and thermal anchor movement, concentrated mass effects, and equipment qualification for piping loads. Eight vent lines off the feedwater and main steamlines adjacent to the steam generators were found to require modification because of the large seismic and thermal movements of the steam generators. In addition, one pipe support on each residual heat removal pump required modification because of the anchor movement of the pumps. Therefore, the equipment sample was expanded to include equipment where the potential for high seismic and thermal displacements exists. Equipment such as the reactor coolant pumps, steam generators, pressurizer, and residual heat removal pumps were included in the review. All piping associated with such equipment was reviewed and qualified.

Seismic Class I piping attached to certain equipment, which was not originally specified as seismic Class I, was also found to exert loads beyond equipment capacity. This equipment was recently seismically qualified for the Hosgri event, but had not been reviewed. PG&E stated in the Phase I Final Report that all such equipment will be reviewed and qualified as appropriate.

Small-Bore-Piping Supports

During the DCP verification of seismic Class I small-bore-piping supports, the same approach was used as that which was used for the verification of the small-bore piping. The generic review of these supports included a comprehensive review of the following items:

(1) standard support details
(2) loads from seismic and thermal piping anchor movement
(3) code boundary interfaces
(4) lug stress and local lug effects on pipe stress

Sampling methods were used to ensure qualification of supports where the items above did not require consideration, and to address design considerations not included in the generic review. The sampling process was expected to confirm that these design considerations did not cause small-bore-support modifications. If this was not the case, then further review was performed.

The locations of a seismic Class I/Class II pipe interfaces, load combinations, and allowable stress criteria are the same as for large-bore-piping supports. Small-bore-piping supports are also required to have a natural frequency of 20 Hz or greater in the restrained direction.

All standard support details were reviewed and recalculated as necessary to identify the maximum permissible load. Consideration of revised Hosgri spectra was included in this review. If the supporting capability was reduced below acceptable limits, the affected supports were identified and corrected. Supports that provide the first restraint in each direction on a branch pipe attached to a larger diameter pipe were reviewed to ensure compliance with stress criteria including the effect of the seismic and thermal anchor movement of the large pipe. Likewise, those supports that serve to isolate seismic Class II from Class I piping were reviewed to ensure qualification to seismic Class I support design criteria.

Analyses were performed, based on the maximum allowable pipe span for lug support configurations, to determine a maximum acceleration allowable to maintain the pipe lug and local pipe within stress limits. The results of these analyses identify areas of the plant where specific review of lug designs would be necessary or demonstrate that lugs would be acceptable at all plant locations.

A sample review of the supports located on lines subjected to temperatures of 350°F or greater was performed to demonstrate that supports designed by span criteria for seismic loads only are conservative when compared to the actual computer-analyzed thermal plus seismic loads. Ten isometric drawings selected at random were used for the sample.

The qualification of pipe supports for the cumulative effect of overspans pipe insulation weight, revised spectra, concentrated masses, pipe as-built configuration, and equipment and building anchor movement considerations is demonstrated by qualification to established acceptance criteria of all supports associated with the corresponding small-bore-pipe sample.

As a result of the DCP review and reanalysis, a total of 1150 small-bore supports have been modified. Of these, 60% were required to meet revised seismic Class I/ Class II interface criteria and 21% were required as a result of the large-bore-piping review. The remaining 19% resulted from the generic and sample reviews. Specifically, revised specification of code boundaries resulted in 682 support modifications, and revised seismic and thermal piping anchor movements resulted in 32 pipe support modifications. The generic reviews of piping previously computer analyzed, and hot piping, resulted in 121 support modifications. Determination of the load capacity of the standard small-bore-piping supports resulted in 49 support modifications.

The sample review of pipe supports, previously designed by span criteria and subjected to thermal loads, indicated that all supports meet the revised span criteria. Likewise, the sample review of randomly selected pipe supports indicated that no support modifications were necessary.

The sample review to check lug local stress has not been completed. The current review indicates that no support modifications are necessary.

3.3.2.2 IDVP Effort

The IDVP reviewed the adequacy and application of the span rules used for qualifying small-bore piping. This review was performed by Robert L. Cloud and Associates (RLCA) and reported in ITR 30.

Small-bore piping is usually defined as piping that is less than or equal to 2 in. nominal diameter. It has been general industry practice to support piping of this size using installation rules for placement of supports, known as "span rules," which are intended to ensure a conservative design in lieu of more detailed computer analysis.

For Diablo Canyon Unit 1, span rules were also applied to seismic Class I piping in the range of 2½-4 in. nominal pipe size in diameter. The Hosgri report also permitted qualification of 6 in. pipes by span rules. Therefore, for purposes of review the IDVP expanded the definition of small-bore piping to include any seismic Class I piping qualified only through the use of span rules.

Verification of Initial Sample

The IDVP performed a review of an initial sample of small-bore piping. This review included the selection of the sample, generic verification of the span rules, and field verification of span rule implementation. The IDVP selected a sample of two sets of piping. One set was used to verify the span rules generically, and the second set was used to verify the implementation of the span rules.

The set used to verify the span rules generically was selected considering the following parameters: pipe size, material, temperatures, pressures, and natural frequency. Parameters were chosen to reflect both those likely to coincide with minimum design margins and those most commonly used throughout the plant. This sample consisted of four hypothetical piping configurations.

The set used to verify span rule implementation consisted of three lengths of piping, each about 150 ft in length. Complex piping configurations that were not specifically addressed in the span rules (i.e., situations resolved by engineering judgment) were not included within this set. That portion of the review was deferred to the IDVP verification of DCP corrective action.

The IDVP generic verification of span rules, applied to the first set, considered the following load cases: pressure, deadweight, and the Hosgri earthquake. Spectra were prepared and a stress analysis was performed for all load cases. The load cases were combined as specified in the Hosgri report and the resulting stresses were compared to the licensing criteria. The effect of welded attachments to the piping was also considered as part of this review.

The IDVP verification of PG&E span rules determined that pipe stress for small-bore piping supported with PG&E span rules meets the licensing criteria for Hosgri conditions.

A field verification of the second set addressed the following:

(1) conformance of plant "as-built" configurations to span rule requirements

(2) documentation of support types and locations

(3) reasonableness of IDVP analysis assumptions within the generic review of span rules described above as to lug details, insulation thickness, and other items.

Field verification of span rule implementation showed that, for the sample, all piping was installed in accordance with the span rules. Although pipe routing and support design configurations were observed that were not specifically permitted within the span rules, it was recognized that span rules cannot anticipate every possible configuration and that such rules must be implemented by engineers capable of exercising good engineering judgment. The IDVP deferred the review of specific instances where engineering judgment was necessary to the verification of the DCP corrective action.

Ten Error or Open Item (EOI) files were issued by the IDVP as a result of the initial review and were classified as follows (see Section 1 for definitions):

Finding	1098
Combined with findings	1058, 1059
Observations	1043, 1045, 1046
Closed items	1024, 1044, 1047, 1048

Except for EOIs 1058 and 1059, all EOIs were issued to note differences between the field condition and design drawings. All these were closed as deviations when further review indicated the correct quantities or dimensions were used in the design analyses. EOI 1058 was issued to note the possible exceedance of allowable stresses for certain lug stresses. EOI 1059 was issued to note three discrepancies:

(1) The PG&E report shows certain pipe stresses above allowable values, and some frequencies below 15 Hz.

(2) The preliminary (1969) Blume report does not address span conservatism as implied in the Hosgri report.

(3) The span tables do not address insulation weight of 6-in. piping. This error was ultimately combined with EOI 1098 as a class A/B error.

Although the span rules generally satisfied the licensing criteria, the following generic concerns were noted:

(1) The span rules do not address insulated pipe.

(2) The span rules do not limit the areas where small-bore piping is installed and may not satisfy licensing criteria for high seismic response areas.

(3) The Hosgri report allows the design of 6-in. pipe by the span rules, but these rules do not consider 6-in. pipe.

(4) The fundamental frequencies for some span rule configurations are less than 15 Hz.

(5) For 3- and 4-in. pipe, the span rules do not limit the unsupported distance from a change of direction containing a axially restrained run of pipe.

(6) A demonstration of the conservatism of the span rule approach was not presented in the Blume report, as implied in the Hosgri report.

In addition, the use of engineering judgment, the verification of maximum vertical and horizontal spans, and the field marking of hangers were items also noted.

These concerns were reported to DCP and will be addressed in the DCP Corrective Action Program. The IDVP will verify that these concerns have been addressed and implemented through the IDVP verification of the DCP Corrective Action Program.

3.3.2.3 IDVP Verification of DCP Corrective Actions

The IDVP verification process of DCP corrective actions on small-bore piping and supports is defined in ITRs 8 and 35.

Small-Bore Piping

The IDVP verification consisted of examining the qualification of small-bore piping for all seismic and nonseismic loads. The IDVP performed design reviews for the DCP analyses selected. A design review checklist was developed for the IDVP review of computer-analyzed piping to ensure that all necessary items were examined and documented in a standard format. These checklists cover all essential areas of review from modeling/coding accuracy of piping and valves and application of stress evaluation to qualification of valve acceleration and nozzle loads.

Also, the IDVP performed selected field verification of the sample computer-analyzed piping to assess the adequacy for the piping walkdown isometric drawings that served as a basis for the computer model input.

The IDVP performed design reviews on the application of the span rules calculations. These span rules are listed in DCP Design Criteria Memorandum M-40 (DCM-40). The IDVP reviews of these calculations included seismic spans and corresponding accelerations, thermal flexibility, code break requirements, support of eccentric masses (valves with operators), support loads, pipe stresses, and use of engineering judgment.

In addition to the above types of reviews, the IDVP performed a more general review of the span rules. The areas of special interest and review included scope of applicability, frequency of seismic spans, thermal rules, and spectral acceleration factors. In all of these areas, alternate calculations were performed by the IDVP to assess the effects of various DCP assumptions and calculations where necessary.

The IDVP sample of DCP qualification analyses was selected to ensure conformance to criteria and accuracy of calculations. The sample selected was chosen to assess the essential steps of the qualification process. Specifically, groups of files chosen for review were as follows:

(1) 4 samples out of a total of 81 computer analyses. The IDVP selections focused on piping in high seismic locations and with high temperature operating modes.

(2) 4 samples out of a total of 115 span rule calculation files.

In addition, the DCP span rules were reviewed by the IDVP for methodology and applicability.

No EOIs were issued to date concerning this review of small-bore piping. The IDVP review is not yet complete. On the basis of the efforts performed through June 30, 1983, the IDVP considers the following aspects of the DCP work acceptable:

(1) Computer-Analyzed Piping

(a) The computer-analyzed piping reviewed by the IDVP adequately represented the worst cases for the issues/design considerations determined by generic and sampling reviews.

(b) Piping walkdown isometric drawings reflected as-built conditions.

(c) Stress intensification factors were adequately input.

(d) Piping and valves were adequately modeled.

(e) Seismic analyses used appropriate spectra input.

(f) Thermal operating conditions were input correctly.

(g) Piping and valves met stress and acceleration allowable limits.

(h) Numerical accuracy of the calculations sampled was adequate.

(2) Application of Span Rules

(a) Valves with eccentric operators were properly supported, when required (one case).

(b) Temperatures and thermal flexibility displacements were properly determined.

(c) Seismic spans were in accordance with DCM-40 or were qualified by additional DCP calculations.

(d) Sufficient piping overlap was considered for code break (between safety and nonsafety piping) requirements.

(3) Span Rule Methodology

(a) DCM-40 span rules may be applied for small-bore piping anywhere in the plant as long as spectral acceleration factors are correctly selected and used. Methodology is acceptable and the spectra reviews are continuing.

(b) Support spacing was established so that frequencies for uniform straight pipe spans are approximately 15 Hz. Rules and space reduction factors were provided to evaluate other spans.

<u>Small-Bore-Piping Supports</u>

A design review checklist was developed for the IDVP review of small-bore-piping supports to ensure that all necessary items were examined and documented. Checklist observations were further expanded with comments where clarification or more detailed consideration was appropriate. In addition to the checklist, the IDVP design review included assessments of the completeness, applicability, and consistency of the DCP review and reanalysis methodology.

The IDVP performed an analysis package and pipe support review to evaluate the completeness of all pertinent design input data, output results, and associated documentation.

Alternate calculations were performed by the IDVP, where necessary, to assess the effects of various DCP assumptions and to confirm calculations.

The IDVP selected a sample of 12 DCP small-bore-pipe-support analyses to ensure conformance to DCP criteria and accuracy of calculations. The selection process included the following:

(1) The DCP list of small-bore-piping-supports that comprised the full DCP review sample (approximately 210 supports) was reviewed by the IDVP.

(2) Supports were selected to represent various support types, pipe sizes, plant locations, and organizations (consultants) performing design analyses.

(3) In general, the selected supports were associated with piping that was part of the IDVP small-bore-piping sample.

(4) Several supports were selected as a result of IDVP field-verification activities for piping samples.

No EOIs have been issued as of this date. The IDVP review is not yet complete. On the basis of the efforts performed to June 30, 1983, the IDVP considers the following aspects of the DCP work to be acceptable:

(1) The small-bore-piping supports analyzed by the DCP adequately represent the worst cases for the issues/design considerations determined by their generic and sampling reviews.

(2) Support drawings are satisfactory.

(3) Pipe support drawings and information used in the analyses reflect the as-built conditions.

(4) Loads and load combinations used in the pipe support analyses are correct.

(5) Standard component supports such as spring hangers, snubbers, and pipe clamps are satisfactory.

(6) Four analyses meet criteria.

3.3.2.4 Staff Evaluation

The staff has reviewed and evaluated the submittals by the DCP and the IDVP on small-bore piping and supports.

The DCP has conducted an extensive review and has stated that this piping and its supports satisfy the criteria under which Diablo Canyon Unit 1 was initially licensed. This was determined through an extensive reevaluation and verification of the piping designs and as-built configurations, which led to a considerable number of support modifications. The nature of these modifications was not described in the DCP report.

The DCP report is unclear as to the actual extent of the review. The scope of the review states that all seismic Class I small-bore piping was reviewed for compliance with the original design criteria. However, there is no clear indication that the piping reviewed under the generic review and the piping reviewed under the sample review comprise the total small-bore piping. In addition, from the sense in which the report is written it appears that the evaluation has as yet not been completed.

The IDVP has reviewed the revised span rules and verified their implementation in design and construction. A number of concerns were identified which have apparently been resolved. This was reported in the IDVP verification of the

DCP Corrective Action Program. However, the IDVP review has as yet not been completed. The IDVP has stated that a final conclusion on the qualification of small-bore piping and supports and their conformance to licensing criteria will be reported in future ITRs when all analyses have been evaluated by the IDVP. The staff will review the reports and will present the results of its evaluation of small-bore piping and small-bore-piping supports in a future supplement to the SER.

3.4 Equipment and Supports

3.4.1 Mechanical Equipment and Supports

3.4.1.1 DCP Effort

The Diablo Canyon Project (DCP) has reviewed all seismic Class I plant equipment listed in the Mechanical Equipment and Component Section of Table 3.2-4 of the FSAR and Tables 7-5, 7-5A, and 7-6 of the Hosgri report, to identify equipment required for seismic qualification. Mechanical equipment includes valves, pumps, heat exchangers, and tanks. Qualification to DE, DDE, and Hosgri events is required for all equipment except for the equipment of the gaseous radwaste system, which is required to be qualified to DE only.

The specific load combinations and allowable stresses used for qualification of equipment are those listed in FSAR Section 3.9 and Hosgri report Tables 7-1 and 7-2. The load combination for Hosgri seismic loading consists of dead load, pressure, operating loads, and nozzle loads. The spectra used for checking seismic qualification were taken from Design Criteria Memoranda DCM-C-17, C-25, and C-30. The damping values that were used in the reanalysis were taken from Table 3.7 of the FSAR.

The DCP seismic qualification for all equipment was performed as follows:

(1) The spectra used for qualification were compared with the current controlled spectra, using appropriate damping values. For Hosgri spectra, the envelope of the Blume and Newmark horizontal spectral curves were used.

(2) Seismic spectra applicable for each component were systematically reviewed in a controlled fashion each time revised spectra were issued, to determine whether or not equipment seismic calculations needed to be revised. An evaluation and comparison was made with previous qualifying spectra, and reanalysis and modification were performed where necessary.

All of the equipment analyses were reviewed and updated or reanalyzed to ensure equipment structural integrity and, if required, functional capability. The review checked for correct seismic, gravitational, operating, and nozzle loadings. Where functional capability was required, clearances between rotating and static components were checked against deflections to ensure that contact would not occur. Field inspections were conducted to confirm as-built details.

The equipment was checked by one of the following methods:

(1) If the minimum resonant frequency classified the equipment as being in the flexible range, dynamic finite-element modeling was used. The computer

programs used were ME210, BSAP and ICES STRUDL II, which are applicant-verified computer programs.

(2) If the equipment was in the rigid range, the seismic loadings were static loads associated with the spectra zero-period accelerations. The finite element models also were used for the static loading cases where the complex nature of the equipment necessitated a detailed model. For simple equipment such as a fuel oil filter, a calculation was considered adequate.

(3) The portable diesel fire pump was qualified by testing on a shake table. The loading during testing exceeded the envelope of the Hosgri and DDE spectra. The containment hydrogen purge system supply and exhaust blowers were qualified by drop testing to "g" levels well above the appropriate spectra curves.

(4) Nozzle loads were factored into the analyses as they became available in the course of the Phase I piping program. If the nozzle loads exceeded the allowable loads on the equipment, then either the calculated loads were reduced by more refined analytical techniques or the piping system was modified to reduce the loads and/or the equipment was modified to accept the nozzle loads.

The results of the DCP mechanical equipment review are listed in Table 2.3.1-1 of the DCP report. Each analysis is stated to have demonstrated that the equipment is qualified to perform its safety function without modification for the controlling spectra and load combination. However, this Table also shows that the following equipment is not qualified for the nozzle loads:

(1) boric acid tank
(2) CCW heat exchanger
(3) CCW pump lube oil cooler
(4) diesel generator
(5) diesel transfer filter
(6) waste gas compressor

DCP anticipates that this equipment or support may be modified or that the calculated loads will be reduced by further analysis. In addition, field verification of some component configurations has as yet not been completed, such as the ventilation system water supply and exhaust blowers and motors, the ASW pump and motor, and the containment fan cooler box. Finally, because not all final spectra have been issued, some of the calculations may have to be revised to ensure that the affected equipment is qualified.

3.4.1.2 IDVP Effort

The mechanical equipment and supports that the IDVP verified for seismic adequacy, consisted of samples of tanks, valves, pumps, and heat exchangers. The verification was performed for the IDVP by Robert L. Cloud and Associates (RLCA).

For all equipment the IDVP performed an independent analysis of a sample of each item, a field verification of the selected equipment, and a comparison of the installed configuration and dimensions against both the DC design drawings and design calculations. The IDVP used standard dynamic analysis and stress analysis methods in performing their independent calculations. Both conventional calculations and standard, bench-marked computer programs and solutions were employed in this effort. The verification analysis included an evaluation of not only the equipment itself, but the equipment support including anchorage. The Hosgri loading combinations and structural criteria used in the independent evaluation were taken from the Hosgri report.

The results of the independent analyses and evaluations were compared to both the governing criteria and the design analysis results. The IDVP issued an ITR on each category of equipment describing the analysis procedures and assumptions used, the results and comparison of results, EOIs, generic concerns, and conclusions. Summaries of these are presented below.

The IDVP initial sample calculations did result in identification of certain deficiencies that warranted additional verification. The initial sample findings and recommended additional verification for each category of structures, systems and equipment are described in ITR 1. For the mechanical equipment sample, additional verification was performed for pumps. The extent and results of the additional verification effort for this equipment is also discussed below.

In addition to equipment-specific concerns, the IDVP identified generic concerns related to the control and use of the correct seismic spectra. The IDVP also verified that the DCP has addressed these Hosgri-spectra concerns in the Corrective Action Program.

The IDVP also reported the verification of non-Hosgri aspects of mechanical equipment as defined by ITR 35. It stated that the DCP has reviewed all seismic Class I (or 1E) mechanical equipment. The IDVP Phase II sample of mechanical equipment included a tank, heat exchanger, valve, fan, compressor, pump, and mechanical filter. The verification emphasized differences from the Hosgri qualifications, particularly when the non-Hosgri qualifications are controlling.

Overall analytical modeling techniques and methodology were evaluated on the basis of consistency with the as-built condition. Selected details and dimensions in the qualification analyses were field verified on a sample basis to ensure that required modifications were made.

<u>Tanks</u>

The tank initial sample consisted of the boric acid, starting air receiver, and the diesel generator oil priming tanks. The verification effort included a field verification of physical dimensions, independent seismic and structural analyses, and a comparison of independent and design analysis results. This effort is reported in ITR 3.

For each tank, RLCA performed the following:

(1) verified the tank's physical dimensions in the field

(2) modeled the tank as a series of beams and lumped masses to determine the stiffness and the natural frequency

(3) determined seismic acceleration using the natural frequency together with the applicable Hosgri response spectra

(4) calculated forces and moments at key areas using the equivalent static method

(5) computed stresses and loads at key areas such as nozzle attachments, anchor bolts, and so forth

(6) compared the computed stresses and loads to allowable stresses and loads as designated by the licensing criteria

A model based on the stiffness properties of the boric acid tank and skirt was used to derive the response of the tank-fluid system. This response was then compared with the design analysis results. The largest stresses at the anchor bolt and skirt were computed and compared to the allowable stress criteria. All the independently calculated loads and stresses were shown to be below the corresponding allowable values. Because of differences in analytical techniques, the design analysis results could not be directly compared with the independent analysis results. However, both approaches were considered to be applicable and the resulting stresses were found to be very low.

For the starting air receiver vertical tank the equivalent static method was used to calculate tank seismic forces and loads. A computer analysis was used to determine the local pressure discontinuity stresses at the support skirt-to-tank juncture. The comparison of the computed stresses with the allowable stresses did not indicate any overstress or overload condition. Except for the different analytical techniques used and conservative damping values considered in the design analysis, a comparison of the design and verification analysis revealed no gross differences in the results.

For the diesel generating oil priming tank, the frequency and the applicable seismic acceleration were determined using the stiffness values of the tank supporting structure and the attached level indicator. Loads and stresses on component parts were obtained by applying the acceleration values.

In addition, the buckling load was calculated for the upper support. The stresses independently computed were well below the allowable stresses (or loads).

Different analytical techniques were used for the verification and design analysis of the oil priming tank and minor discrepancies in the design analysis were noted. The stress values determined for the selected areas were much lower than those of the design analysis. A discrepancy in the level indicator stresses was a result of conservative calculations by RLCA and the difference in the level indicator weight.

Seven EOIs (one on boric acid tank, two on starting air receiver tank, and four on oil priming tank) were issued and were resolved as follows (see Section 1 for definitions):

Findings	None
Observations	1011, 1017, 1030, 1053
Closed items	1012, 1015, 1054

Since no findings were issued, this initial sample of tanks constitutes the entire Hosgri sample on mechanical tanks. Consequently, no additional sampling or verification was required or performed.

Valves

The auxiliary feedwater valve (FCV-95) and the main steam isolation valve (FCV-41) were identified as the initial sample. Valve FCV-95 is motor operated and is physically located in the auxiliary building. Valve FCV-41 is air operated and is located on the pipeway outside of the containment building.

Results of the RLCA review of the initial valve sample were reported in ITR 37. The review methodology included independent calculations and field verification of design input quantities. In addition, the IDVP performed field verification of physical modifications resulting from the initial sample review. Applications of loading combinations and structural design criteria were based on the Hosgri report (see FSAR Amendment 51). The stress limits are specified in Table 7-1 of the Hosgri report. The IDVP effort consisted of the following:

(1) The equipment physical dimensions and other design data were obtained from drawings and field measurements.

(2) Analytical models were developed for frequency, stress, and deflection analysis.

(3) Seismic accelerations in combination with other loads were applied to the analytical models to calculate the seismic response of the valves.

(4) Calculated stresses were compared to the Hosgri structural criteria, and deflection clearances were evaluated.

(5) Results of the verification analysis were compared with the PG&E design analyses. Differences were evaluated for significance.

In general RLCA used more rigorous and detailed analytical techniques than PG&E used. In many cases this, combined with the diversity in conservatism of assumptions, loadings, and boundary conditions, accounted for differences in the results in excess of the 15% criteria. In all cases the calculated stresses were within the allowable values for both the verification analysis and the design analysis. Five EOIs were issued and were resolved as follows:

Finding	None
Observation	950
Closed items	998, 999, 1082, 1116

The one observation, EOI 950, was the result of a discrepancy in stiffener plate thickness determined from the field verification. Although the IDVP did not consider physical modifications of FCV-95 to be necessary to satisfy criteria, the DCP modified the valve by replacing a 3/8-in.-thick plate with a plate of the ½-in.-design thickness. The IDVP verified this modification. No additional sampling or verification of valves was required.

Pumps

The following pumps were identified as the initial sample:

(1) turbine-driven auxiliary feedwater (TAFW) pump
(2) auxiliary salt water (ASW) pump
(3) component cooling water (CCW) pump

The TAFW and CCW pumps are physically located in the auxiliary building. The ASW pump is located in the intake structure.

Based on the initial sample verification results, additional verification was performed on the fuel oil transfer (FOT) pump and the motor-driven auxiliary feedwater (MAFW) pump.

The results of the RLCA review of the initial pump sample were reported in ITR 32. The review methodology included independent calculations and field verification of design input quantities. Applications of loading combinations and structural design criteria were based on the Hosgri report. Stress limits for pumps are specified in Table 7-1 of the Hosgri report for active pumps and in Table 7-2 for pump supports.

The RLCA effort consisted of the following:

(1) The equipment physical dimensions and other design data were obtained from drawings and field measurements.

(2) Analytical models were developed for frequency, stress, and deflection analysis.

(3) The Hosgri response spectra in combination with other loads were applied to the analytical models to calculate seismic response of the pump.

(4) Calculated stresses were compared to the Hosgri structural criteria, and deflection clearances were evaluated.

(5) Results of the verification analysis were compared with the PG&E design analyses. Differences were evaluated for significance.

In general RLCA used more rigorous and detailed analytical techniques than PG&E. In many cases this, combined with the diversity in conservatism of assumptions, loadings, and boundary conditions, accounted for differences in results in excess of the 15% criteria. In all cases the calculated stresses were within the allowable values for both the verification analysis and the design analysis. Six EOIs were issued and resolved as follows:

Finding	1022
Observations	1020, 1072, 1073, 1114
Closed item	1113

None of these EOIs required action involving a physical modification. EOI 1022 was issued in connection with response spectra input to the ASW pump, and was redefined to track the DCP seismic reevaluation of the intake structure. EOIs 1073 and 1114 were also issued in connection with the ASW pump. The error C classification of EOI 1073 originated from the improper application of dynamic response calculation methods. EOI 1114 reflected failure to consider the pump as a partially submerged structure when evaluating seismic response. These errors did not impact the acceptability of the specific pumps. However, they did result in required additional verification.

This additional verification was performed for the sample previously identified. The specific objective of this verification was to address certain calculational deficiencies identified by EOIs 1073 and 1114. The review of the additional Hosgri pump sample confirmed that the design analyses of these pumps did not contain these deficiencies.

Heat Exchangers

The initial sample consisted of the component cooling water heat exchanger, the only heat exchanger analyzed by PG&E and/or its seismic service-related contractors for Hosgri qualification. The verification effort included a field verification of the support configuration, independent seismic and structural analyses, and a comparison of independent and design analysis results.

The independent analysis and review of the initial sample of heat exchangers is summarized in ITR 43. The RLCA effort consisted of the following:

(1) The heat exchanger's dimensions and support configurations in the field were verified.

(2) A detailed model was developed for the verification analysis.

(3) An integrated analysis considering all combinations of loads to evaluate all key areas of the heat exchanger was performed.

(4) Loads and stresses for the as-built configuration were calculated and compared with the design analysis for accuracy and consistency commensurate with the Hosgri criteria.

The IDVP listed a number of deficiencies of the design analysis procedures used by PG&E. Major deficiencies were:

(1) The as-built support configuration was not used to generate seismic loads.

(2) Nozzle loads were not included in the evaluation of the entire support structure and shell.

(3) The effect of the additional load produced by the constraint of attached piping during the heat exchanger seismic inertial movement was not considered in the evaluation.

Generally, the verification and design analyses used different approaches to analyze the heat exchanger. The verification analysis calculated shell stresses resulting from actual combined seismic, deadweight, pressure, and nozzle loads and compared these stresses to the allowable values. The design analysis calculated shell stresses as a function of the seismic acceleration plus pressure and deadweight loads. These stresses were set equal to the allowable values to determine the maximum seismic capability of the shell.

Because different approaches were used in the verification and design analyses, they yielded different results that could not be directly compared. Both analyses, however, determined that the heat exchanger shell stresses were below the allowable values for Hosgri loading conditions. Based on the verification results, three EOIs were issued and classified as follows:

Finding	None
Observations	978, 1088, 1099
Closed item	None

Since the component cooling water heat exchanger was the only heat exchanger in the IDVP scope required for Hosgri qualification and the verification results showed that all stresses were below the allowable values, no additional verification or sampling was considered necessary.

3.4.1.3 Staff Evaluation of IDVP Effort

The staff's review of the IDVP Final Report and the ITRs of the topics listed in Section 3.4.1.2 of this report follows.

Tanks

The technical data presented in ITR 3 was not sufficient to define completely the geometry of the tanks being considered or the methods used in their verification. On the basis of the report alone a judgment could not be made of the adequacy of the verification effort. Therefore, an audit was performed by the staff of the work on which the ITR is based. The results of the audit indicated that in most cases the RLCA evaluations were more comprehensive than the PG&E design calculations, i.e., RLCA computed stresses at more locations or considered more design features than did PG&E in their original design calculations. However, the tanks were originally designed to a version of Section VIII of the ASME Boiler and Pressure Vessel Code, which before the Hosgri report did not require as comprehensive an analysis as the one performed by RLCA. RLCA followed current engineering practice in performing this review.

The staff finds, after the ITR review and the audit, that the evaluation procedures and methodology used by RLCA are acceptable. Although based on simplified seismic models, calculations, and limited computer analysis, the evaluation is in general more comprehensive than the original design calculations. Additionally, the calculations are supported by field verifications of the tank configuration and good quality control of the evaluation basis. The staff, therefore, finds the verification effort by the IDVP of the PG&E design analysis of tanks acceptable.

Valves

The procedures described by RLCA in performing the independent analysis and verification of valves in ITR 37 are acceptable and would be expected to reveal any deficiencies in the PG&E design analysis reviewed. The information provided in the report is insufficient to allow any judgment of the correctness of the RLCA models or analysis results. However, audits of other RLCA analyses have indicated proper application of analytical and modeling principles.

This ITR addresses the verification of valve extended structures only. The Hosgri report specifies loading combination and stress allowables for active valves and pumps and their supports in Tables 7-1 and 7-2. For the nozzles, the extreme fiber stress in the piping at the nozzle-pipe interface is required to be smaller than the yield stress under the combined loading. For the valves in this report it is unknown if this condition is satisfied in the piping system of which they are a part.

After additional communication with RLCA, they indicated that this concern will be addressed and reported in the verification of DCP Corrective Action Program. Subject to this commitment, the staff finds the verification by the IDVP described in this ITR acceptable.

Pumps

The procedures followed by RLCA in performing the independent analysis and verification of pumps in ITR 32 are acceptable and did reveal deficiencies in the PG&E design analyses. For the most part, the models used by RLCA were designed to provide conservative results and were judged to be as sophisticated as the models used in the design analyses. All reported stresses were found to be below the allowables; therefore, the pumps evaluated appear to meet the licensing criteria. However, for the auxiliary salt water pump, no results were presented for either the pump impeller shaft stresses and deflections or the impeller shaft bearing loads, if any. In addition, no discharge head nozzle stresses were reported or compared to an allowable stress. However, after further communication, RLCA stated it had performed a followup evaluation of these items and that the highest calculated stresses and loads were considerably below the allowable stresses. The staff, therefore, finds the verification by the IDVP of the PG&E design analysis of pumps described in this ITR acceptable.

Heat Exchangers

The RLCA review and verification analysis of the component cooling water heat exchanger in ITR 43 seems both detailed and comprehensive. The models used were judged to be more sophisticated and complete than the models used in the original design analyses. All reported stresses and loads were found to satisfy the allowables. Certain items needed clarification on the basis and method of calculation. This clarification was provided by RLCA, through further communication, and found acceptable. The verification effort by the IDVP of the PGE design analysis of the CCW heat exchanger described in this ITR is, therefore, acceptable.

3.4.1.4 IDVP Verification of DCP Corrective Actions

The IDVP verification of DCP work on mechanical equipment is defined by ITRs 8 and 35. The following two aspects were emphasized:

(1) verification of the PG&E review methodology to ensure that the correct spectra were checked by PG&E against qualification analyses

(2) completeness of qualification

The IDVP performed a design review for the DCP reanalysis. A checklist was developed that covered all required criteria items and critical analytical procedures and that ensured completeness of the IDVP review. In addition to the checklist, the IDVP review included assessments of the completeness, applicability, consistency, and adequacy of the DCP review and reanalysis methodology. Where discrepancies were noted, or methodology was deemed not totally appropriate, alternate calculations were carried out by the IDVP to verify the conclusions of the DCP reanalysis.

The DCP Corrective Action Program for equipment consisted of a review of the seismic qualification, implemented by checking the latest seismic qualification data against those used for the qualification of equipment. This check used the latest response spectra for the DE, DDE, and Hosgri events. Whenever changes to the response spectra required requalification of the equipment, the equipment was requalified by analysis or testing.

<u>Tanks</u>

The CCW surge tank was selected as the IDVP verification sample of the DCP implementation. The CCW surge tank is a seismic Class I tank and is located atop the auxiliary building at el 163 ft. This tank is classified and built to ASME Code, Section VIII (Rules for Construction of Pressure Vessels). This is one of five mechanical tanks reviewed by the DCP. Of the five, three were verified for Hosgri loadings as part of the initial sample. Of the two remaining tanks, only the CCW surge tank was required to be evaluated for both DE and DDE loadings.

The IDVP issued EOI 1136, which notes that the DCP analysis for the CCW surge tank calculated bolt shear stress allowables that did not conform to established DCP criteria and the ASME Code. However, the bolt stresses remain below the correct allowable values. The DCP analysis also did not consider internal pressure-induced stress in the tank for the evaluation of tank stresses at the nozzle. Tank stresses would exceed the specified allowable stress if pressure was considered using the same values and procedures as the DCP analysis. However, it was determined that the DCP reanalysis was very conservative and the actual pressure stresses were negligible. Thus, actual total stresses were below criteria.

The IDVP review for tanks is not yet complete. On the basis of the efforts performed to June 30, 1983, the IDVP considers that the following aspects of the DCP work are acceptable and satisfy the licensing criteria:

(1) The seismic spectra utilized by the DCP for tanks reflects the current spectra.

(2) The mathematical modeling used in the reanalysis was considered to be acceptable.

(3) All established DCP criteria are considered to have been adequately met.

The items identified in EOI 1136 are considered to be random analytical discrepancies.

Valves

The DCP Corrective Action Program for valves is closely tied to the DCP efforts for piping. Certain valves were selected by the DCP for reanalysis to determine valve natural frequencies and allowable accelerations. These valves had been originally qualified by seismic, service-related contractors to PG&E. Only motor-operated valves with eccentric masses were reanalyzed. The allowable acceleration results were then used in the piping analysis to determine if modifications to the valve or pipe supporting structure were required.

An electrohydraulic valve was selected as the IDVP verification sample. The valve is a seismic Class I level control valve located on the pipeway structure outside the containment building. It is one of the six different types of valves analyzed as part of the DCP's ITP. This type of valve was selected for the IDVP review sample because a similar valve had caused an overstress condition in the pipe line in one of the IDVP initial sample piping analyses (EOI 1069). In addition, the actuator motor on these valves had been replaced.

Actual piping accelerations as well as any additional valve support bracing were not included in this portion of the review because the results of this DCP reanalysis are to be used as criteria for the piping system qualification.

No EOIs have been issued in this review area to date.

The IDVP review for valves is not yet complete. On the basis of the efforts performed to June 30, 1983, the IDVP considers that the following aspects of the DCP work are acceptable and satisfy the licensing criteria.

(1) The methods and results of the reanalysis comply with the established DCP criteria.

(2) Mathematical modeling of the valve adequately represents the structure of the valve.

(3) Critical areas were examined.

Pumps

Two identical fire pumps located in the Unit 1 auxiliary building at el 115 ft were selected as the IDVP verification sample. The fire pumps are seismic Class I equipment.

This pump is one of eight pumps reviewed by the DCP. Of these eight, one was qualified by shake table testing and, thus, is excluded from the sampling of reviewed/reanalyzed pumps. Five of the remaining seven pumps were included in the IDVP initial sample and additional verification work. Thus, with the IDVP review of the fire pump, six of the seven pumps qualified by analysis and in the IDVP scope have been verified.

The IDVP review for pumps is not yet complete. On the basis of the efforts performed to June 30, 1983, the IDVP considers the following aspects of the DCP work to be acceptable:

(1) Operability, as defined by rotating element clearances and interferences, was adequately demonstrated.

(2) The seismic spectra utilized by the DCP for pumps reflects the current spectra.

(3) The mathematical modeling used in the reanalysis was judged to be acceptable for the fire pump.

(4) With the exception of the item identified in the next paragraph all established DCP criteria are judged to have been adequately met.

The IDVP has determined that the flanges on pumps require reevaluation. This aspect of the DCP work, therefore, is considered an unresolved concern at this time.

Heat Exchangers

The CCW pump lube oil cooler was selected as the IDVP verification sample of the DCP's ITP activities for heat exchangers. One lube oil cooler is mounted with each of the three CCW pumps located in the auxiliary building at el. 73 ft. The CCW pump lube oil coolers are seismic Class I equipment. This cooler, or heat exchanger, is one of two heat exchangers reviewed by the DCP. The other was the CCW heat exchanger, which was in the IDVP initial sample.

EOI 1130 was established and was resolved as a deviation.

The IDVP review for heat exchangers is not yet complete. On the basis of the efforts performed to June 30, 1983, the IDVP considers the following aspects of the DCP work to be acceptable:

(1) Seismic spectra utilized in the reanalysis were the current spectra.

(2) The methods and results of the reanalysis reviewed comply with the established DCP criteria.

(3) Mathematical modeling adequately represented the cooler structure.

(4) Because all DCP-reviewed heat exchangers are included in the IDVP, all such heat exchangers have been verified as complying with criteria.

The IDVP intends to formulate a final conclusion as to the qualification of all mechanical equipment and its conformance to licensing criteria when all IDVP verification work in this area is complete. This will be reported in ITR 67. A review and evaluation of this ITR will be reported in a future supplement to the SER.

3.4.1.5 Staff Evaluation

The staff has reviewed and evaluated the submittals by the DCP and the IDVP on mechanical equipment and supports.

The DCP has conducted an extensive review of the seismic Class I mechanical equipment previously qualified to DE, DDE, and Hosgri seismic loading. The review was performed using currently accepted design methodology and the load combinations specified in the FSAR and the Hosgri report. Acceptance criteria for qualification were also those specified in the FSAR and the Hosgri report. Equipment and supports were evaluated concurrently.

The DCP reported the results of their review in Table 2.3.1-1 of the PG&E Phase I Final Report. Each analysis was stated to have demonstrated that the equipment is qualified to perform its intended safety function. However, the same table shows that in six equipment items the calculated nozzle loads exceeded the allowable nozzle loads. In addition, some component configurations as yet have not been verified nor have all final spectra been issued. DCP has indicated that some of this equipment or the supports may have to be reanalyzed or modified to accommodate the nozzle criteria or the final seismic spectra. The staff concludes that not all mechanical equipment as yet is seismically qualified to perform its intended safety function.

The IDVP performed an extensive independent analyses of a sample of each major equipment category. It used standard and acceptable dynamic analysis and stress analysis methods in performing its calculations on the equipment, equipment supports and anchorages. Field verification of the selected equipment also was performed and compared with the installed configuration and Diablo Canyon design drawings. Results of the calculations were compared to the design calculations and the design criteria listed in the Hosgri report, and published in ITRs 3, 37, 32, and 43.

Based on their initial sample calculations the IDVP identified certain deficiencies that warranted additional verification and generic concerns related to the control and use of correct seismic spectra.

The IDVP also has reported the verification of DCP activities in the DCP Corrective Action Program. It is currently reviewing the DCP efforts to ensure that the concerns stated by IDVP in the initial and subsequent independent verification are being addressed in the DCP Corrective Action Program. The IDVP has concluded that based on the current verification effort no major deficiencies in the DCP Corrective Action Program have been uncovered and that based on the IDVP independent evaluation of a sample of equipment, the equipment at Diablo Canyon Unit 1 appears to meet the established design criteria. This effort is, however, as yet incomplete.

The completed verification effort by the IDVP of the DCP Corrective Action Program on mechanical equipment will be reported in ITR 67. The staff review of this ITR will be reported in a future supplement to the SER.

3.4.2 Heating, Ventilation, and Air Conditioning Equipment

3.4.2.1 Introduction

The heating, ventilation and air conditioning (HVAC) system provides ventilation, heating, and cooling to safety-related systems. The HVAC system must withstand the effects of the DE, DDE, and Hosgri events; therefore, the systems are designated seismic Class I. The HVAC includes the following aspects and systems:

(1) forced draft shutter
(2) diesel generator compartment ductwork
(3) auxiliary saltwater compartment ventilation
(4) 4-kV switchgear ventilation
(5) dc 480-V switchgear ventilation
(6) auxiliary building, fuel-handling building
(7) control room ventilation and pressurization system

The HVAC system consists of compressors, fans, dampers, filters, heaters, ductwork, registers and diffusers, controllers, valves, position indicators, motors, thermostats, and control panels.

The primary sources of data used by the staff in its evaluation are listed below.

(1) IDVP Diablo Canyon Nuclear Power Plant- Unit 1 Final Report

(2) Pacific Gas and Electric Company Phase I Final Report Design Verification Program

3.4.2.2 IDVP Effort

The IDVP reviewed two samples of the DCP verification of all the seismic Class I HVAC equipment. These samples were (1) the supply fan S-1 and (2) the compressor CP-35.

The supply fan S-1 is located in the auxiliary building at el 85 ft. There is another identical fan, S-2, located on the same elevation. The compressor CP-35 and an identical compressor, CP-36, are located in the auxiliary building at el 154 ft 6 in. The fan sample was selected on a random basis with a bias toward larger units. The compressors chosen were the only ones evaluated by the DCP.

For both samples the IDVP performed a design review of the DCP reanalysis. This design review included assessments on the completeness, applicability, consistency, and adequacy of the DCP review and reanalysis methods. Where descrepancies were noted, or methods deemed not totally appropriate, alternate IDVP calculations were made to verify the conclusions of the DCP reanalysis.

The IDVP review is not complete as of June 30 1983. However, the IDVP has issued EOIs 1125 and 1127 as a result of the verification work done as of June 30, 1983.

EOI 1125 dealt with use of incorrect spectra for vertical accelerations for the compressor. The EOI was classified as error class C. Later analyses using the corrected spectra showed no overstress condition prevailed; therefore, the EOI was closed.

EOI 1127 was issued because of two concerns over modeling techniques used in the evaluation of the fans. The concerns were resolved as being not significant based on the IDVP analysis. The item was therefore closed.

On the basis of the efforts performed as of June 30, 1983, the IDVP considers that the following aspects of the DCP verification work are acceptable and satisfy the licensing criteria:

(1) The mathematical modeling of the structure was found to be adequate.

(2) Application and satisfaction of established DCP criteria were found to be adequate.

(3) A concern did exist over the proper control and application of seismic spectra, an issue that was related to work done in the initial sample.

The IDVP intends to formulate a final conclusion as to the qualification of the DCP verification program and conformance to licensing criteria when its review is complete.

3.4.2.3 DCP Effort

The DCP verification of the HVAC equipment consisted of a review of the newest seismic qualification data against data used for the qualification of the equipment. The specific procedure used by the DCP was to

(1) compile area drawings that documented safety-related HVAC equipment locations

(2) list all equipment within this area and to document the method of qualification to applicable seismic spectra

(3) review the method of qualification and to qualify any equipment that was not qualified to seismic criteria

    (a) If spectra did not change for a particular location it was documented and no action taken.

    (b) If the spectra affecting certain items were not identical to the previous qualifying spectra, a comparison and evaluation were made. However, if the spectra did not affect the seismic qualification of the item, the reason was documented and a copy was placed in the system file.

    (c) If the spectra affected the seismic qualification of a component, an analysis or test was performed and the results were issued. The documentation was updated.

    (d) A redesign was performed and the equipment was modified, as required.

The DCP compiled a list of the equipment and components of the seismic Class I HVAC systems. They were reviewed for seismic qualification in accordance with the current spectra defined in the PG&E's Hosgri, DE, and DDE events. These items were also reviewed against the acceptance criteria for seismically qualifying them.

Where the most current spectra exceeded the conditions under which the component was previously analyzed, a new analysis was initiated. The results of the analysis either confirmed qualification of the component or identified a physical modification. Where analysis was not appropriate, equipment testing was used to demonstrate the designed performance under the qualifying seismic conditions.

3.4.2.4 Staff Evaluation

Two samples out of 26 fans and 4 compressors were selected for the IDPV review. The compressor was selected for verification based on concerns from the initial sample. The fan was selected on a random basis with a bias toward physically larger units. The review of the IDVP to this point has shown that the HVAC equipment was adequately modeled and the DCP criteria application was found to be adequate. The IDVP review is not complete as yet and the IDVP will provide the final conclusion in a future ITR. The staff will fully evaluate the IDVP review when it is completed and the final report is provided to the staff.

The DCP review of the equipment consisted of a review of the newest seismic qualification data against data used for the original qualification. This check was performed using the latest response spectra for the DE, DDE, and Hosgri events. When changes to the response spectra required requalification of the equipment, this was done by analysis or testing. The verification program of the IDVP is not yet complete. The staff will complete its evaluation when the IDVP review is completed.

3.4.2.5 Conclusion

The final report on the IDVP review is not available at this time and no staff conclusions on the review are possible.

3.4.3 Electrical Equipment and Instruments and Supports

3.4.3.1 Introduction

The electrical raceway support system contains approximately 460 standard designs used in the Diablo Canyon plant. There are more than 21,000 safety-class electrical raceway supports in Unit 1. Each design has been generically qualified to carry a certain number of cables/trays and to be installed in particular areas of the plant. The support locations are based on allowable-span criteria. The supports are constructed primarily of bolted assemblies of cold-formed-steel channel sections and spaced 8 ft 6 in. apart or less. They support cable trays and conduit on walls and beneath floor slabs in most of the buildings throughout the plant. The Phase I review of the electrical raceways was based on a sample of 20 raceway supports, and the verification of DCP corrective action was based on a second sample of 20 raceway supports.

Class I instrument tubing is tubing containing a fluid that runs between a transducer in the system being monitored and a display device at a remote location. The tubing is small in diameter (typically 1/4 in.) and composed of stainless steel or copper. The tubing supports are typically made of standard cold-formed members, welded together or assembled with standard fastener devices. The majority of Class I instrument tubing and supports associated with Class I safety-related instrumentation is within the containment structure. There also are isolated systems in both the auxiliary and turbine buildings. These instrument sensing lines supply pressurized fluid signals to the Class I instrumentation.

The primary sources of data used by the staff in its evaluation are

(1) IDVP Diablo Canyon Nuclear Power Plant-Unit 1 Final Report

(2) Pacific Gas and Electric Company Phase I Final Report Design Verification Program

(3) IDVP Interim Technical Report 7, "Electrical Raceway Supports"

3.4.3.2 IDVP Effort

Electrical Raceways

The IDVP review of the electrical raceways included the following items for verification of the initial sample:

(1) evaluation of design criteria/methodology
(2) determination of applicable Hosgri response spectra
(3) sample selection
(4) documentation of actual sample configuration at the plant

The IDVP used a number of PG&E documents such as preliminary criteria memoranda, qualification analyses, and drawings to evaluate the design criteria/methodology. The Hosgri report was reviewed for applicable response spectra at the sample raceway support locations. Following the response spectra review, the IDVP selected a sample of 20 electrical raceway supports at various elevations and locations in each of the four safety-related structures. The sample was selected on the basis of the judgment of the IDVP as to which supports would have the least margin of safety. Supports with long cantilever arms, relatively large supported mass, and long raceway spans were typically selected. Once this sample was selected the IDVP documented the as-built configuration by making physical measurements in the field.

The IDVP identified the following five concerns that relate to the design criteria/methodology:

(1) Longitudinal support for conduits was not specified in any installation drawing and was not checked by PG&E in the qualification analysis.

(2) Raceway stresses calculated for the largest design span may exceed allowables.

(3) Joint fatigue and local joint flexibility may result in more flexible supports that are characterized by higher seismic response.

(4) Flexibility of adjacent supports may change the effective load distribution of the support being examined, resulting in higher seismic response of individual supports.

(5) The design methodology did not consider the coupling of support and raceway in determining natural frequency.

The following four additional concerns were raised as a result of physical measurements taken at the plant:

(1) Sample 3 was installed with larger members than were specified in the original design drawings.

(2) Sample 4 has an additional 1-in. conduit attached to the support, which exceeded the specified maximum support capability.

(3) Sample 15 was secured to a wall with a less conservative anchor bolt configuration than specified on the design drawings.

(4) Sample 20 was installed in an area not specifically authorized by the design drawing.

Seven EOIs were opened as a result of the review (983, 1026, 910, 930, 1010, 1093, and 1097). Two were classified as error class A or A/B or B and three were not classified. EOIs 910, 930, and 1010 were combined with EOI 983 for tracking purposes. EOI 1026 was redesignated to cover the DCP turbine building review and EOIs 1093 and 1097 relate to the auxiliary building. The auxiliary building is evaluated in Section 3.2.4.

EOI 983 will be used to track the DCP activities in response to the ITR 7 recommendations that the DCP should

(1) modify design criteria and methodology used to seismically qualify electrical raceway supports

(2) define Hosgri response spectra inputs for all electrical raceway supports

(3) establish and implement a program to ensure that raceway supports conform to design installation criteria

<u>IDVP Verification of Electrical Raceways</u>

The IDVP verification of the DCP Corrective Action Program is not complete as yet. The IDVP will provide a detailed description of the process and results in a future ITR. The staff will fully evaluate the IDVP review when it is completed and the report is provided to the staff.

The IDVP has provided some information in the IDVP Final Report, and this information was used by the staff to assess the status and direction of the IDVP efforts.

The DCP Corrective Action Program included a physical survey and documentation of the location of each electrical raceway support, characterized by support type, generic qualification of support types using worst-case seismic response spectra, and alternative qualification of support types using worst-case "as-built" information for each individual support within such a support category.

The scope of the IDVP review of the DCP Corrective Action Program included the following categories of Class 1E electrical raceway and raceway support analyses:

(1) transverse and vertical support qualifications
(2) longitudinal support qualification
(3) conduit span qualification
(4) EOI resolutions

For Categories 1 and 2, the IDVP selected a sample of analyses as the basis for design reviews. Categories 3 and 4 were each contained in a single calculation package and were reviewed completely by the IDVP. The IDVP review process included review of the methodology and criteria, design review of the qualification analyses, and field verification of as-built configurations used as input to the analyses.

The IDVP verification of the transverse and vertical support qualifications, and the longitudinal support qualification was accomplished through field verification of site conditions and design review of the qualification analyses. The design reviews were performed using technical checklists developed to reflect procedures and criteria documented in PG&E DCM C-15, Rev. 3. For the conduit span calculations and EOI resolutions, the IDVP reviewed the design calculations using checklists developed specifically for each type of calculation and field verified a sample of the as-built information used as input to the analyses.

The IDVP sample for the transverse and vertical qualifications were chosen as representative of a variety of configurations, locations, loading conditions, and analysis type. The IDVP selected 17 analyses from approximately 460 support type analyses.

The IDVP reviewed the complete scope of the DCP analysis for the cable tray and conduit span qualification.

The IDVP selected a total of five samples of the cable tray and conduit analyses for runs in various locations to review the longitudinal qualification. An additional sample will be taken to verify analyses performed by a consultant of the DCP. The consultant's analyses were not complete when the IDVP made its preliminary sample. The DCP has performed a dynamic analyses for longitudinal motion, which will be reviewed by the IDVP.

No EOIs have been issued as a result of the IDVP review of the DCP Corrective Action Program as of the date of the Final Report.

The IDVP review is not complete at this time. The results of the verification will be documented in a future ITR. The IDVP considered the following aspects of the DCP work to be acceptable based on the IDVP efforts up to June 30, 1983:

(1) Field verification of a sample of the supports showed a satisfactory correlation with the drawings.

(2) Nine analyses followed procedures and were accurate within a satisfactory tolerance.

Instrument Tubing and Tubing Supports

The instrument tubing and tubing supports were not part of the initial IDVP Phase I program but were added later. The IDVP, therefore, did not define an initial sample or conduct any review. The IDVP verification scope consisted of verification of all Class I instrument tubing and tubing supports located in areas of the containment annulus structure that were affected by the revised response spectra. The DCP Corrective Action Program on this subject was based on 88 tubing supports in specific areas of the containment annulus structure and generic qualification of tubing spans on a plant-wide basis, using worst-case assumptions concerning Hosgri response spectra. The 88 supports reviewed constitute all the tubing support types.

The methodology adopted by the IDVP for review of the DCP Corrective Active Program included review of the completeness, applicability, and consistency of the procedures and criteria implemented in the DCP design review of the six qualification-analysis packages and field verification of the input to the qualification analyses.

The IDVP review of the DCP program implementation was based on a 100% sample of the DCP program for instrument tubing and supports. The DCP Corrective Action Program implementation is contained in six qualification-analysis packages, which make up the IDVP scope for design review. One of the six packages contains the generic tubing span qualifications. The remaining five contain tubing support qualifications based on a DCP walkdown to identify controlling or specific worst-case configurations in specific areas of the annulus structure.

The basic criterion utilized by the DCP to qualify instrument tubing supports is to ensure that the supports are rigid. Rigidity is based on a minimum frequency of 33 Hz. Those supports found not to be rigid were qualified by stress analyses utilizing criteria established for pipe supports (DCM M-9). To qualify the tubing, a worst-case analysis was performed to show that regardless of resonance, the tubing spans using the original support spacing did not experience stresses exceeding allowables.

EOI 1123 was issued as a result of the use of incorrect member properties for a particular support type. The member properties were different from both the DCP documented as-built information and that which was confirmed by IDVP field verification. The EOI is unresolved as of June 30, 1983.

The IDVP review is not yet complete. The results of the IDVP will be reported in a future ITR.

Based on the IDVP review as of June 30, 1983, the IDVP considers the following aspects of the DCP Corrective Action Program to be acceptable:

(1) Four DCP qualification analyses have been verified to be sufficient and in conformance with licensing requirements.

(2) The DCP provided sufficient and accurate "as-built" survey documentation supporting DCP qualification analyses for 12 support types.

3.4.3.3 DCP Effort

Electrical Raceways

The DCP review of the electrical raceways consisted of ensuring that the methods used previously in the DDE and Hosgri analyses adequately represented the as-built conditions. This review included checking the weights of cables, trays, and conduits and the structural adequacy of the supports. The review indicated that some of the weights used in the original design were less than actual weight; therefore, tray and conduit supports were reanalyzed. The reanalysis of the electrical raceway supports also considered the effects of any structural response spectra changes.

The horizontal response acceleration was taken as the greater of the two building responses resulting from either the east-west or the north-south ground motion combined, by absolute sum, with the corresponding torsional response. The damping value for cable tray systems and conduit systems used in these evaluations was 7%. The horizontal component of seismic load (either transverse or longitudinal to the raceways) that resulted in the highest stress on the member under consideration was combined, by absolute sum, with the stresses or forces resulting from dead load and vertical seismic load.

The specifications used to review the design of the steel members were the American Iron and Steel Institute (AISI) "Specifications for Design of Cold-Formed Steel Structural Members" and Part I of the American Institute of Steel Construction (AISC) "Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings" applicable to hot-rolled members. The allowable stress given in the AISC specifications was increased by 60%. The allowable stress given in the AISI specifications was increased, so that the margin of safety against yielding was 1.0 or greater with the allowance for local yielding at connections.

Allowable loads on bolts were taken as 90% of the manufacturer's recommended ultimate values. The allowable loads on concrete expansion anchors were taken as twice the working load permitted in PG&E Engineering Standard. The capacities in this standard represent a safety factor of 3.0 or above, based on test values published by the Pittsburgh Testing Laboratory and Phillips Drill Company, as well as PG&E tests performed at the plant site. The acceptance limit on fillet welds on cold-formed-steel members was 60% greater than the allowable given in Section 4.2.1 of AISI "Specifications for Design of Cold-formed Steel Structural Members." Unbraced ceiling mounted joints made of angle fitting were being checked against rotation and low-cycle fatigue.

In the transverse direction, the seismic loads used in the evaluation of the supports were based on the frequency of the cable tray supports. The mass considered acting at the support was the mass of the support itself and the tributary mass of the supported trays.

Each support was evaluated for the generic condition representing a worst-case condition. This condition was determined by considering the variations in the location within the plant, sizes and numbers of raceway trays, signs of trays, support dimensions and bracing locations. Any type of support that could not be qualified for its generic case was investigated in the plant to determine the worst as-built conditions using the field location of the support, dimensions of the support, bracing configuration, sizes and locations of raceways in the support, span lengths, and raceway identification numbers so that actual weights of raceways were determined. Using this information, static analyses were again performed for each support of that type in the same mannner as for the generic case, except that in this case as-built parameters were used, including the frequency of the as-built to determine the accelerations.

The cable trays were provided with longitudinal seismic braces. The evaluation of these braces was similar to the transverse analyses.

Design modifications were prepared for supports that could not be qualified based on as-built conditions. Field modifications were carried out in the plant for the supports affected.

The conduit supports were analyzed in the same manner as the cable tray supports for the transverse direction. The conduit supports do not have the longitudinal bracing that was provided in the cable tray system.

To quantify the longitudinal resistance of the electrical conduit system, a program was initiated to select and analyze those systems most susceptible to worst-case longitudinal loading. All Class 1E conduit runs were documented for their as-built conditions. Those runs that were vulnerable to longitudinal loading were identified and analyzed as systems.

Sixteen of the most heavily loaded and longitudinally flexible runs were selected for dynamic analyses. These represented the limiting cases that had little or no apparent longitudinal supports. Finite-element models of the selected conduit runs were then developed. Dynamic analyses of each of these runs were performed to determine the response behavior and to calculate the loads resulting from floor response spectra. These loads were then used to evaluate the safety factor associated with critical components of the supports.

A simplified but more conservative procedure was developed to evaluate the remaining runs identified for analyses. Those runs whose first mode of vibration in the longitudinal direction had a frequency less than 33 Hz were stiffened by the addition of longitudinal braces to reach at least 33 Hz. The total seismic load in any conduit run was calculated using equivalent static analysis and the zero period acceleration (ZPA) of the appropriate floor response spectra. This load was distributed among the supports proportionally to their longitudinal stiffness. The loads on each support were used to evaluate the safety factors associated with critical components of the supports. If the results of the simplified analysis were too conservative, the conduit run was dynamically analyzed. Design modifications were prepared for the supports that exceeded the acceptance criteria. Field modifications were carried out in the plant for supports affected.

The modifications required to date for raceway supports were limited to adding a simple bracing made of 1-3/4 in. by 1-3/4 in. angle iron, or additional welding around angle fittings, so that support members could develop additional moment capacity.

Instrument Tubing and Tubing Supports

The review of safety-related instrumentation tubing and tubing supports consisted of checking the rigidity of tubing and supports for the Hosgri event. A field walkdown was performed to determine the enveloping of supports that had the longest cantilever or the heaviest loads and resulted in 88 support configurations. The natural frequency was determined and compared to 33 Hz, the criteria for rigidity. If the support frequency was larger than 33 Hz, no further review was necessary. If the structural frequency was less than 33 Hz, the supports were analyzed. If the supports were found to be inadequate, they were modified as necessary and reviewed to determine the implication on supports outside the sample.

Two tubing supports were found to be inadequate. These supports were modified and reviewed for generic implications. A walkdown of the entire plant did not identify any other supports with the two deficiencies.

The original instrument tubing was supported to maintain a tubing frequency of at least 20 Hz. The tubing was evaluated for this frequency and none were found to exceed allowable stresses.

3.4.3.4 Staff Evaluation

IDVP Effort

The IDVP review of the raceway supports consisted of independent initial review of a sample of 20 raceway supports and verification of the DCP effort by reviewing an additional sample of 20 supports. The IDVP initial review discovered inadequacies and issued EOIs, accordingly. The EOIs have been combined to reduce the amount of items outstanding, but the tracking of PG&E activities was maintained. The activities of the IDVP are not complete and the results will be documented in a future ITR. The staff finds the IDVP efforts in the area of the electrical raceway and instrument tubing and supports are adequate and should lead to an acceptable conclusion. The staff will review the results of the IDVP review when the ITR is issued and formulate its conclusion.

DCP Effort

The DCP review of the electrical raceway and instrument tubing and supports seems to be leading to a satisfactory conclusion and qualification.

The report, as filed, does not address the qualifications of the cable trays themselves or how the flexibility of the cable trays interact with the supports. This subject should be addressed. In addition, the DCP in a separate effort established through testing of field samples the allowable limits for welds used in superstrut construction. These limits should be used in the qualification of the cable trays supported by superstrut material.

3.4.3.5 Conclusions

The verification of the DCP review has not been completed by the IDVP. The staff cannot formulate a conclusion on the adequacy of the electrical raceways and instrument tubing and supports until the IDVP has filed its Final Report.

3.5 Other Seismic Design Verification Topics

3.5.1 Soils and Foundations

3.5.1.1 Introduction

R. F. Reedy, Inc., (RFR) performed quality assurance (QA) review of PG&E and their seismic service-related contractors which included the firm of Harding Lawson Associates (HLA). The QA review revealed that HLA did not implement a QA program for the DCNPP soils work performed for the Hosgri qualification analyses before June 1978. HLA's geotechnical work included intake structure, outdoor water storage tanks, buried diesel fuel oil tanks and connecting lines, and buried auxiliary saltwater piping. As a result of the QA review, RLCA and its consultant, Abendruh, Inc., formulated and carried out a review of HLA's soils work. In this section the term RLCA represents the TES/RLCA team that carried out the geotechnical portion of the IDVP.

RLCA selected the following topics and samples of HLA's soils work for an independent design verification.

(1) outdoor water storage tanks (OWST)

- (a) lithology of rock
- (b) bearing capacity

(2) intake structure

- (a) lithology and properties of backfill material
- (b) bearing capacity
- (c) lateral pressures
- (d) sliding resistance

RLCA reported its findings in a series of Interim Technical Reports (ITRs) and the IDVP Final Report. ITR 16 presents results of the RLCA review of the OWST and ITRs 13, 39, and 40 present the results of the RLCA review of the intake structure. RLCA also evaluated the effect of lack of QA on HLA's soils work and independently verified HLA's work for Hosgri qualification analyses. This report is based on the documents referenced.

3.5.1.2 Outdoor Water Storage Tanks

The OWSTs are situated on the east side of the auxiliary/fuel-handling building and are approximately 40 ft in diameter and 50 ft high. These steel tanks were originally founded on a compacted fill placed over the bedrock. Following the Hosgri evaluation in 1978, the compacted fill under these tanks was replaced with concrete and the steel tanks were encased in concrete. ITR 16 presents the RLCA review of HLA's geotechnical work for the OWSTs and includes review of lithology of rock and allowable bearing capacity of the bedrock.

The geotechnical investigations for the OWSTs performed by HLA in 1973 and 1978 included borings, laboratory tests on recovered samples, and geophysical tests in the borings. RLCA reviewed information in HLA's reports on the bedrock depth (bedrock profile), description of the bedrock, and strength properties of the bedrock.

RLCA verified the location of borings and the depth to bedrock by comparing information from HLA's field logs and reports and PG&E's drawings. RLCA's verification revealed a discrepancy in the location of two borings. These were addressed in EOIs 1101 and 1100 and were classified as Class D, deviation error. The errors were the result of incorrect descriptions of structures used as landmark references in locating the borings. The RLCA rectified this error and the location of the borings now shown in the HLA reports and field logs and the PG&E drawings are consistent and correct.

The discrepancies in both the location of borings and depth to the bedrock are minor and within variations normally encountered in field explorations. The staff agrees with RLCA's conclusion that the HLAs determination of depth to the bedrock at OWSTs was based on consistent set of data and is acceptable.

RLCA compared the description of the bedrock in the HLA reports and field logs and in reports by others on previous investigations (Blume studies, 1968 and 1969) at this site. RLCA concluded that the description of the bedrock as presented in the HLA report was consistent with the description given in the HLA field logs and the Blume reports.

The bedrock is moderately weathered, hard, fine-to-medium-grained sandstone and occasional silt stone. HLA assigned strength parameters of 4 ksf for cohesion and 35° for angle of internal friction for the sandstone. RLCA reviewed the results of two confined compression tests by HLA on samples of moderately to deeply weathered sandstone. RLCA plotted data from one test along with the HLA recommended strength parameters. These two matched very well. RLCA concluded that the HLA assigned strength parameters were, therefore, acceptable.

ITR 16 does not present the value of the modulus of elasticity used by HLA in their analysis. RLCA calculated the modulus of elasticity for the bedrock using data from the geophysical survey performed in general vicinity of the OWSTs and assigned the lowest computed value 500 ksi to the bedrock. RLCA concluded that the modulus of elasticity (500 ksi) was acceptable for the bedrock in the area of the OWSTs.

Although the data base is minimal, the staff judges that the recommended strength parameters are reasonable and are within values generally quoted in the literature for sandstone. The staff agrees with the RLCA conclusion.

HLA recommended an allowable bearing pressure of 80 ksf for the OWSTs. RLCA independently evaluated the ultimate bearing capacity and concluded that the 80 ksf allowable bearing pressure recommended by HLA for the OWSTs foundation was acceptable. The staff agrees with the RLCA conclusion.

HLA did not estimate the settlement of OWSTs. RLCA calculated the settlement to be 0.5 in. for a maximum bearing pressure of 80 ksf and concluded that the computed maximum settlement was not detrimental to the structure. The staff agrees with the RLCA conclusion.

Evaluation of dynamic loading conditions was not part of HLA's soils work and hence was not selected for review by RLCA.

3.5.1.3 Intake Structure

The intake structure is a reinforced concrete building founded on a grout mudmat that was poured directly over the bedrock. Three sides of the structure are backfilled to plant grade. The fourth side (west) of the structure has no backfill and has openings to admit sea water to the intake pumps. In 1978, several years after the intake structure was constructed, HLA drilled borings in the backfill material down to the top of bedrock and performed a geophysical survey in these borings to obtain data for the Hosgri evaluation of the DCNPP. RLCA's review of HLA's work for the intake structure is reported in ITRs 13, 39, and 40. ITR 13 reports on lithology and properties of the backfill material. ITR 39 reports on the strength and bearing capacity of the rock and the lateral pressures on the walls of the intake structure. ITR 40 reports on the sliding resistance of the intake structure.

RLCA verified the bedrock depth by comparing information from the HLA field logs and reports and the PG&E drawings (1978 investigations). The boring locations shown in the above three sets of data matched reasonably well, except for the location of hole no. 3. The error, offset indicated as west rather than east, was attributed to a typing error on plate 1 of the HLA report. EOI 1094 documented this error and classified it as Class D, deviation error. This error was corrected. This comparison verified that the bedrock depth used in HLA's soils report and subsequent work is appropriate. The staff agrees with RLCA's conclusion.

RLCA verified HLA's definition of backfill material properties as follows:

(1) RLCA independently calculated soil parameters using actual laboratory test data originally reported by HLA. The test results reported by HLA agreed with the values independently calculated by RLCA.

(2) For the backfill samples, the soil classifications assigned by the geologist on the field logs were compared with the soil classifications assigned to the same samples by the soils laboratory technician. The field classification and laboratory classification were in general agreement. The classification by the laboratory technician was again verified by RLCA on the basis of laboratory test results. This procedure verified the soil classifications given in HLA's soils report.

(3) The reported unconfined compressive strength and corresponding field blowcount data for the test samples were compared with the strength and blowcount values from published literature. The comparison verified that the strength of the backfill material mentioned in HLA's soils report was of the same order of magnitude as that published in the literature for soils of comparable blowcount resistance.

Based on the above comparisons, RLCA concluded that HLA's definition of the properties of the backfill material is acceptable. The staff agrees with RLCA on the soils data but finds the scope of verification lacking because it did not define the stratigraphy and numerical values of the properties of the backfill material. RLCA plans to revise ITR 13.

HLA inspected the foundation excavation for the intake structure in 1972 and their inspection memorandum describes the bedrock as moderately hard, moderately strong tuff and shale with minor weathering. All the borings at the intake structure were drilled only to the top of the bedrock. In the absence of any data on the bedrock at the intake structure, HLA used data from a 1968 investigation. Two unconsolidated, undrained shear-strength tests were performed by HLA on samples of tuff recovered from borings drilled for the intake line. Both of these tests were conducted at the same confining pressure and yielded comparable results. For the bedrock at the intake structure HLA assigned strength parameters of 3 ksf for cohesion and 30° for angle of internal friction.

By comparing information from the HLA field logs and reports and the PG&E drawings for the 1968 study, RLCA verified rock data such as location of borings, grade elevation, bedrock depth, and description of rock samples. The data were consistent, except that the location of borings nos. 18 through 22 were shown along the "discharge line" in the HLA report, whereas they were actually along the "intake line." To validate the HLA-assigned rock strength parameters for the intake structure, RLCA compared them with the strength parameters recommended by HLA for the bedrock at the turbine building and at the OWST (c = 4 ksf, 0 = 35°, see Figure 4 in ITR 39). RLCA compared the compressive strength measured (15 ksf) in tests with the compressive strength quoted (76 ksf) in the literature for tuff and stated that the strength values from HLA tests can be considered as a low-bound value for the overall strength of the bedrock at the intake structure. RLCA concluded that the HLA-assigned strength parameters are reasonable and acceptable for the bedrock at the intake structure.

Although the data base is minimal, the staff is of the opinion that the assigned rock strength parameters at the intake structure are within the values generally quoted in the literature for similar rock and are reasonable and acceptable.

HLA recommended an allowable bearing capacity of 33 ksf for the bedrock. RLCA computed the ultimate bearing capacity of the bedrock by assigning several sets of possible strength parameters for the bedrock and demonstrated the conservatism in HLA's recommendation. RLCA concluded that HLA's recommendation is conservative and acceptable.

HLA did not estimate the settlement of the intake structure. RLCA assigned a Young's modulus (500 ksi) and Poisson's ratio (0.39) for the bedrock, both obtained from the geophysical tests performed for the OWSTs. RLCA estimated that a load of 33 ksf uniform bearing pressure would result in 0.75 in. of settlement. Also, a differential load of 23 ksf will cause a 0.5 in. of differential settlement. RLCA concluded that the HLA's recommendation of 33 ksf allowable bearing pressure for the bedrock under the intake structure is acceptable for rock strength and settlement considerations.

During the technical audit meeting at RLCA's office (Jagannath to Lear memorandum, July 11, 1983), the staff was informed by RLCA representatives that the maximum static bearing pressure under the intake structure is 10.16 ksf and there is a local maximum bearing pressure of 26 ksf, under a pier. Considering that the actual bearing pressures are low the staff concludes that bearing capacity and settlement are satisfactory for the intake structure. The staff also concurs with RLCA's conclusion on the bearing capacity recommendation by HLA.

The intake structure is backfilled along three sides and the fourth side (west side) is open to admit sea water to the intake pumps. The bottom of the mat foundation is approximately 49 ft below the grade along the three backfilled sides and 7 ft below grade along the open side. The soil backfill along three sides is approximately 36 ft high on top of the bedrock and the bottom of the foundation is embedded approximately 13 ft below the top of the bedrock. On the west side there is no soil backfill and the foundation is embedded 7 ft below the top of bedrock.

For the backfill material, HLA assigned strength parameters of 35° for angle of internal friction and zero for cohesion. HLA calculated the lateral earth and water pressures on the east wall resulting from static and dynamic loading conditions (Hosgri SSE). The structure is postulated to slide westerly; hence, lateral pressures on the east wall of the intake structure were computed. For the static loading condition, the lateral earth pressure was computed for the at-rest earth condition. For the dynamic loading condition, the lateral earth pressure increment was computed for the dynamic active soil condition using a simplified method recommended by Seed and Whitman (1970). This computed dynamic active earth pressure was multiplied by 3 to compensate for the simplified assumptions in the analyses. HLA also computed the lateral water pressure for both static and dynamic loading conditions. HLA combined water and earth lateral pressures for static and dynamic loading conditions to obtain the total lateral force on the wall.

RLCA verified HLA's work by independently calculating the lateral pressures on the intake structure wall. For the backfill material, RLCA assigned strength parameters of 45° for angle of internal friction and zero for cohesion. For the static loading condition, the lateral earth pressure was computed for the active earth condition. For the dynamic loading condition, the lateral earth pressure increment was computed using the Mononobe-Okabe method as modified by Seed and Whitman (1970). RLCA assumed the dynamic active earth pressure increment had a distribution with depth similar to that used for braced excavations to obtain the lateral earth pressure on a rigid wall. RLCA also computed the lateral water pressure for both static and dynamic loading conditions. Water and earth lateral pressures for both static and dynamic loading conditions were combined to obtain the total lateral force on the wall. The total lateral force computed by RLCA was within 10% of the lateral force computed by HLA. RLCA, therefore, concluded that HLA's determination of the lateral pressures on the wall is acceptable to IDVP.

RLCA's report (ITR 39) does not present a justification for the simplified assumptions in the analyses, the sensitivity of the estimated lateral forces to those assumptions, and the conservatism in the analyses. In the absence of this information the staff considers this ITR to be incomplete. The staff conducted a technical audit of the background materials referenced in ITR 39 (Jagannath to Lear memorandum, July 11, 1983). As a result of this audit RLCA has agreed to revise ITR 39 to address the staff concerns. The staff will review the revised ITR and report its findings in a future report.

Figures 3 and 4 of ITR 40 show the foundation configuration for the intake structure. The potential for westerly sliding of the intake structure was investigated by HLA. The sliding surface and sliding resistance factors along this surface were postulated by HLA. The resistance consists of the shear strength of the rock, the coefficient of friction between the concrete foundation and the rock, and the passive resistance of the rock at the western end of the structure. HLA used a shear strength value of 3 ksf for rock, an angle of friction of 30° between the foundation and bedrock, and a passive resistance of twice the rock shear strength. RLCA verified the postulated sliding surface and resistance factors used by HLA, and RLCA concluded that HLA's recommendations were acceptable.

The shear strength parameters used in the analysis are based on limited data, but the staff believes that they are reasonable and agrees with their use. RLCA, however, did not evaluate the total lateral force, total resistance to sliding, and the resulting factor of safety against sliding. This information is vital in assessing the margin of safety against sliding and for this reason the staff considers ITR 40 to be incomplete. RLCA has agreed to revise ITR 40 to address the above concerns. The staff will review the revised ITR and report its findings in a future report.

3.5.1.4 Conclusions

The NRC staff has reviewed the IDVP Final Report and ITRs 13, 16, 39, and 40 prepared by RLCA and concludes the following:

(1) HLA did not enforce a QA program in their Hosgri qualification work for the DCNPP before June 1978. QA review by R. F. Reedy, Inc., resulted in EOIs of Class D, deviation errors, which have been rectified. These errors do not have any significant bearing on the design and/or safety of the structures.

(2) The geotechnical data available for the OWSTs and intake structure are minimal. The design strength parameters were assigned by HLA based on available test data and engineering judgment. RLCA and the NRC staff concur with the HLA on the reasonableness of the assigned strength parameters.

(3) The staff agrees with RLCA's conclusion that HLA's work for the static loading condition of the OWSTs is acceptable.

RLCA is revising ITRs 13, 39, and 40 for the intake structure. The staff will perform an evaluation of the revised reports when they become available and report its findings in a future report.

3.5.2 Shake Table Testing

3.5.2.1 Introduction

PG&E employed testing for certain Class 1E electrical equipment and instrumentation subject to this design verification. For Hosgri qualification, the criteria used are in conformance with Institute of Electrical and Electronics Engineers (IEEE) 344-1975, and Regulatory Guide 1.100, August 1977.

To obtain a representative sample for design verification, RLCA reviewed the list of Class 1E electrical equipment and instrumentation qualified by shake table testing. Seven groups of items, tested at Wyle Labs, were chosen as the sample according to equivalent physical locations to facilitate definition of the required test. RLCA reviewed the initial sample in two segments. The first and major segment was the verification of Wyle grouping and seismic inputs for Class 1E electrical equipment, which were reported in ITR 4. The second segment was the design verification of shake table test mountings used in testing Class 1E electrical equipment. This verification was reported in ITR 44.

3.5.2.2 Verification of Initial Sample: Grouping and Seismic Inputs

The RLCA review of the Wyle grouping and testing sequence is summarized as follows:

(1) Reviewed the test procedure Wyle used to test each of the seven groups of Class 1E electrical equipment and instrumentation.

(2) Verified the location of the electrical equipment and instrumentation included in the seven groups.

(3) Developed worst-case response spectra for each group. These spectra provided the highest seismic accelerations associated with the location of the group.

(4) Made two response spectra comparisons. The RLCA worst-case response spectra (worst case spectra) was compared to the Wyle test response spectra (test spectra). The Wyle target response spectra (target spectra) was compared to the test spectra.

The RLCA worst-case spectra were generated for two time histories (Blume and Newmark) according to building, floor location, elevation, type, and damping. The types of spectra were both vertical and horizontal. The horizontal spectra consisted of effects of east-west translation, north-south translation, east-west torsion, and north-south torsion. The RLCA worst-case horizontal response spectra were developed by adding torsional effects to the translational spectra.

The test response spectra must envelop the required response spectra by at least 10%. Both the RLCA worst-case spectra and Wyle target spectra were developed to represent the required response spectra.

Four EOI reports (1005, 1007, 1013, and 1049) were issued by RLCA as a result of design verification. EOIs 1005, 1007, and 1049 were later closed and EOI 1013 was resolved as a class B error. EOI 1013 was subsequently downgraded and the equipment was demonstrated to be qualified. The resolution of these EOIs were found to be acceptable by the staff.

The staff also concurred with RLCA's recommendation in that the correctness of target response spectra specified for all items shake table tested by PG&E and seismic service-related contractors be subjected to additional verification. RLCA recommended the following four specific actions.

(1) Confirm field locations of all equipment.

(2) Select the applicable Hosgri response spectra.

(3) Develop the worst-case response spectra.

(4) Compare the worst case response spectra to the target response spectra specified in the testing procedures.

3.5.2.3 Verification of Initial Sample of Shake Table Test Mountings

For shake table testing, the test mountings were intended to simulate the inservice condition. For testing convenience, some equipment was mounted to the shake table through an interposing fixture that was intended to simulate the dynamic and structural characteristics of the inservice mounting. Test procedures and test reports were examined to determine the mounting configurations and fixtures (if any) used for the test of each item of equipment. Where the test mountings were identical to the inservice mountings, they were judged to meet criteria.

For equipment with test mountings not identical to inservice configurations, each test mounting was evaluated to determine if it adequately represented the dynamic and structural behavior of the inservice configuration.

Of the 31 electrical equipment items tested, 25 were found to meet criteria. One was classified as an error, and one was excluded from review as being non-Class 1E. The remaining four items (mountings of the main annunciator typewriter, battery charger cabinet, and the snap-lock limit switch) were not reviewed because they have been retested or replaced by the DCP and should therefore be reviewed as part of DCP activities.

Two EOI reports were issued by RLCA: EOI 1119 was classified as a Class C error because the documentation of the test mounting configuration was not sufficient to allow an evaluation of the structural adequacy of the inservice mountings. This mounting was then qualified by DCP analysis, which was verified by the IDVP. EOI 1118 was classified as a deviation. The staff concurs with the above IDVP verification.

3.5.2.4 Verification of DCP Efforts

The IDVP verification of DCP work on shake table testing is documented in ITRs 8 and 35 and in response to IDVP concerns developed during verification for the initial sample. The results of the verification will be reported in ITR 67. The staff evaluation will be made when ITR 67 is issued.

The DCP Internal Technical Program (ITP) of seismic qualification is conducted by checking the latest response spectra for the DE, DDE, and Hosgri events against data used for equipment qualification. Whenever changes to the response spectra required requalification of the equipment, the equipment was requalified by analysis or testing. Equipment identified for review comprised that associated with the engineering safety systems designated by PG&E Phase I Final Report, Section 2.3.

DCP reviewed the validity of the previous seismic qualifications of equipment against current spectra. If the qualifying test response spectra did not completely envelop the current required response spectra, an attempt was made to qualify the equipment by analysis. Otherwise, equipment modifications would be performed and the equipment would be retested.

The sample selected by the IDVP for verification of the DCP's ITP for shake table tested equipment consists of the portable fire pump and radiation monitor RE-14A, both are seismic Class I equipment.

The portable fire pump represents the only shake table tested mechanical equipment. Radiation monitor RE-14A, on the other hand, represents 1 of approximately 27 categories of tested equipment within the electrical equipment and instrumentation scope. For both sample items, the IDVP performed design reviews and test reviews of the qualification documentation.

No EOIs have been issued to date for this review area.

The IDVP review as yet is not complete. The staff agrees with the IDVP's conclusion that based on the efforts performed to June 30, 1983, the following aspects of the DCP work are acceptable and satisfy the licensing criteria.

(1) Applicable criteria have been identified and applied for shake table testing.

(2) Functional capability requirements have been specified and met.

(3) Mounting of the test specimens were either representative of the installed condition or were adequately evaluated.

3.5.2.5 Staff Evaluation

On the basis of its review of the design verification performed to June 30, 1983, by PG&E and IDVP, the staff concluded that for the sample of equipment items and their mountings selected, the seismic qualification using shake table testing is adequately performed and, therefore, acceptable. The staff agrees with the IDVP findings and concurs in the recommendations as stated in Section 3.5.2.2 for additional verification for correctness of target response spectra specified for all items shake table tested by PG&E and seismic, service-related contractors. The final staff conclusion on the overall adequacy of the shake table testing will be made when the IDVP verification of DCP work in this area is completed.

3.5.3 Seismic Qualification--Main Control Board

3.5.3.1 Introduction

The Diablo Canyon Unit 1 Westinghouse main control board (MCB) was procured for PG&E by Westinghouse (W) in accordance with an equipment specification issued in 1971. The W specification required that the MCB should be qualified to 1g horizontal and 0.5g vertical with stresses within allowable limits and for 2g horizontal and 1g vertical stresses should not exceed the yield point. The MCB was supplied by Reliance, and Reliance used a private consultant to qualify the MCB by analysis. The original analysis predicted the lowest natural frequency of the MCB to be above 70 Hz based on a simple analytical model used.

Stresses were analyzed and shown to be well within allowable range. The axial load in one of the bracing members slightly exceeded the allowable load, and the report recommended addition of two bracing members to each end frame. The next phase of reevaluation was caused by the need to evaluate the adequacy of the MCB to the Hosgri earthquake in 1977. The revised seismic input at the base of the MCB produced 1.55g horizontal and 0.81g vertical; this is the original Hosgri input. These values are lower than the original qualification level of 2g horizontal and 1g vertical; thus the MCB was acceptable under 1977 Hosgri evaluation.

The final phase of the MCB qualification developed when the independent design verification program generated new floor response spectra for the auxiliary building. These new floor response spectra, referred to as current Hosgri spectra, indicate higher values of zero-period acceleration (ZPA) for the vertical direction, 1.45g as opposed to the qualification level ZPA of 1.0g. It was during this final evaluation process that the MCB was modeled using field measurements and results of in-situ tests. In-situ tests pointed out the existence of natural frequencies between 15 to 28 Hz, much below 71 Hz--the value of the lowest natural frequency calculated in the original qualification report. Because of the severity of the current Hosgri spectra at the base of the MCB in the 15 to 33 Hz range, W has chosen to retest selected devices that are attached to the MCB. W also has proposed modification of the MCB.

3.5.3.2 Evaluation

The original analysis modeled the MCB as a uniform cantilever beam restrained at the base by the floor. It appears that in fact the MCB behaves as a horizontal beam supported by rigid cantilever frames, and this type of behavior yielded the lower natural frequencies. The modification proposed is to add plates and channels on top of the MCB to strengthen the beam property of the MCB yielding higher natural frequencies. W was requested to ensure that buckling loads in bracing members of the modified MCB are below critical loads with adequate margins.

The floor spectra enveloping the DDE and current Hosgri spectra were used to generate device location spectra by transient analysis. The devices were tested on a shake table at the maximum expected level. Some modifications such as strengthening of device mounts and restraints are expected. The seismic qualification of the auto/manual station was recently completed by shake table testing which the NRC staff witnessed; all other device testing is complete. Other non-Class 1E devices are being analyzed for structural integrity. Also, modifications to the mounting of some non-Class 1E devices are anticipated.

3.5.3.3 Conclusion

On the basis of the review of the characterization of the seismic input to the MCB and the input to the devices located inside the MCB, review of the detailed model of the MCB and correlation of the model properties with results of in-situ dynamic testing, and attention paid to supports and restraints to both Class 1E and non-Class 1E devices within the MCB, the staff concludes that W has performed a thorough investigation of the qualification program for the MCB and that with the completion of all proposed modifications, the MCB should perform satisfactorily. Staff acceptance of the MCB is contingent upon written confirmation of completion of all modifications to the MCB including the devices with the complete qualification documentation being available at a central location for staff audit.

3.6 Brookhaven Analysis

3.6.1 Introduction

During the early stages of evaluating the so-called "diagram error" the staff decided that the complexity of the situation warranted an independent analysis for the containment annulus region in question. With this objective in mind, the staff requested the assistance of Brookhaven National Laboratory (BNL) to perform a best-available analysis for the vertical response of the containment annulus structure, without reference to the time when the original analysis was done nor to the techniques used at that time. BNL completed this effort and the results were issued in NUREG/CR-2834. Subsequently the staff engaged BNL to provide further assistance to the staff in the growing Diablo Canyon verification effort. The specific tasks were

(1) independent analysis of horizontal response of containment annulus structure

(2) seismic and stress analysis of buried diesel oil tanks

(3) detailed evaluation of two piping systems

(4) evaluation of containment spray discharge line

In addition, the staff requested that BNL attend, with the staff, the technical interchange meetings between the IDVP and PG&E at which seismic verification efforts were discussed. The staff requested BNL to participate (1) in technical audits of some of the IDVP organizations, (2) in the review of ITRs pertaining to structural and mechanical issues and aspects, and (3) in the reviews of the PG&E Phase I Final Report and the IDVP Final Report.

The findings and conclusions of the BNL effort have been incorporated in the appropriate sections of this report. The following is a detailed description of the work performed by BNL.

3.6.2 Vertical Response of the Annulus Structure

BNL developed a detailed three-dimensional model of the annulus structure. The model consisted of beam and plate elements. Beam elements were used to model the floor frames as well as the columns of the annulus. Plate elements were used to model the concrete floor at el 140 ft. The crane wall was assumed to be rigid in the vertical direction; thus, it was not incorporated into the model. Finally, the bracing members on various floors of the annulus were not modeled because they were not excited by the vertical excitation.

All design drawings were not available at the initial stages of the work and there were questions and uncertainties about the type of member connectivity.

For this reason, BNL constructed different models for different types of member connectivity pertaining to the beam-to-column connections. These are:

- Model A: All connections are of the shear type.
- Model B: Connections for the floors at el 101 ft and 106 ft are of the moment type, while the others are of the shear type.
- Model C: Connections for the floors at el 101 ft, 106 ft, and 117 ft are of the moment type, while the floor at el 140 ft is of the shear type.

Based on shop drawings transmitted by PG&E later, it was concluded that model B most closely resembled the actual field conditions.

When the original model was being developed, the fixity of the 140-ft slab to the crane wall was considered. It was clear from the drawing detail that the slab was much closer to being simply supported than to being fixed. However, based on slab mass and average equipment loading on the slab, the slab frequencies were found to be about 28 cps for the simply supported case and 43 cps for the rigid case. Both were essentially rigid; therefore, the slab support condition would not be expected to affect the results.

At the request of the IDVP, mode shapes and participation factors were generated for a model D with the crane wall nodes allowed to rotate about each of the horizontal axes. Other boundary conditions were the same as model B.

Modal shapes/frequencies were obtained from the three-dimensional models. Vertical floor response spectra were generated using the time-history method. Frequencies up to 33 Hz were used for this purpose. The effects of integration time steps on the floor spectra were investigated. For the response evaluations the computer program SAP V was used. At the request of the staff, the results from the SAP V were verified against the STRUDL computer program available at the McDonnell Douglas Automation Company. A comparison at the level of floor spectra was made. The results from both computer programs matched well.

After obtaining vertical floor spectra at the nodes of the three-dimensional model, a comparison was made between the BNL results and the corresponding results from the PG&E five-frame model (URS/Blume, 1979). The following three methods of comparison were used:

(1) comparison of fan cooler locations
(2) comparison with average floor spectra
(3) comparison with envelope floor spectra

The average and envelope spectra were obtained from the floor spectra at the nodal points located within sections of the various floors. Those sections were defined according to the five fan cooler locations.

The following conclusions were reached by BNL:

(1) Local modes were important for the response of the annulus structure. Such modes could not be predicted by the PG&E five-frame model.

(2) BNL vertical floor response spectra did not agree with PG&E spectra. Both frequency shifts and differences in amplitude were found. BNL attributed these differences to the following reasons:

   (a) Incorrect mass values were used in the five-frame model.

   (b) Incorrect type of member connectivity was used between the members of the five-frame model.

   (c) A single mass did not adequately represent the dynamic action within sections of the floors.

The BNL vertical seismic analysis and its results were reported in NUREG/CR-2834.

3.6.3 Analysis of Piping Systems

The staff requested BNL to perform a detailed analysis of PG&E piping systems 6-11 and 4A-26 which are described in Section 3.3.1 of this report. BNL developed finite element models for both piping systems. The model of piping system 6-11 consisted of 58 pipe elements, 75 nodes, and 16 boundary elements. The model of piping system 4A-26 consisted of 55 pipe elements, 84 nodes, and 20 boundary elements. Using these models seismic evaluations were carried out using envelope response spectrum methods as well as independent support motion response spectrum methods of analysis.

A number of evaluations were made for the two piping systems. These included

(1) A frequency determination for system 6-11 using the PG&E mathematical model

(2) Frequency determinations using BNL mathematical models

(3) Envelope spectrum evaluations using BNL models and PG&E-supplied spectra. These were performed for X-Y inputs with no clustering, Y-Z inputs with no clustering, and X-Y-Z inputs with clustering.

(4) Envelope spectrum evaluations using BNL models and BNL-developed spectra for annulus structure models A and B for all the calculational modes mentioned under Item (3)

(5) Multiple independent support response spectrum evaluations using the BNL models and BNL-developed spectra for the annulus structure model B considering only X-Y-Z inputs with clustering

(6) ASME Code, Class 2/3 evaluations using BNL models and the annulus structure model B envelope spectra

(7) ASME Code, Class 2/3 evaluations using BNL models and the annulus structure model B individual support spectra.

On the basis of their seismic evaluations of both piping systems (6-11 and 4A-26) BNL concluded:

(1) BNL models developed from PG&E as-built drawings were found to differ from the PG&E models. The differences were due to the use by PG&E of design dimensions which differed from the as-built dimensions and due to errors made by PG&E in the modeling of pipe bends. Also an overlap procedure was used in the modeling of system 4A-26. The extent of overlap used in the system seemed adequate in that it met the intent of NUREG/CR-1980.

(2) BNL predictions of system frequencies differed from the PG&E estimates; however, these differences were not large.

(3) BNL support force values obtained using BNL models and PG&E-supplied spectra did not match. The differences were probably due to the differences in modeling.

(4) Support forces calculated using BNL piping models and BNL 3-D model B envelope or independent spectra substantially exceeded PG&E calculated values. The major cause for this was that model B spectra greatly exceeded the spectra used by PG&E.

(5) ASME Code, Class 2 evaluations performed using the uniform response spectrum method indicated exceedance of service level D stresses at two points in system 6-11, and system 4A-26 satisifed service level D requirements.

(6) ASME Code, Class 2 evaluations performed using the independent support response spectrum methods produced a reduction in stress levels in system 6-11, but an increase in stress levels for system 4A-26. For this procedure, system 6-11 showed slight overstressing at one point, and system 4A-26 still met requirements. It is possible that independent support input excitation analyses based on the time-history methods could produce results which would, depending on phasing, satisfy service level D requirements.

The BNL seismic analyses of PG&E piping systems 6-11 and 4A-26 are reported in detail in NUREG/CR-2834.

3.6.4 Horizontal Response of Containment Annulus Structure

The model of the containment annulus structure was developed from the model used for the vertical analysis and reported in NUREG/CR-2834. The data used to develop the horizontal model were the drawings referenced in the NUREG report and additional material obtained from the Diablo Canyon Project (DCP) up to January 11, 1983. The following changes were made to the vertical model:

(1) All bracing members were added to the floors.

(2) The crane wall was added to the model.

(3) The two pool walls spanning across the crane wall were added.

(4) A solid floor at el 140 ft was added inside the crane wall.

(5) The mass of the equipment (steam generators, pressurizer, and polar crane) and concrete walls at el 140 ft was added.

(6) The vertical displacements and the rotation about each of the horizontal axes (except for those nodes on the crane wall) were restrained.

The SAP V computer program was used to determine the first 40 mode shapes. The frequencies ranged from 2.6 to 27.7 cps. Two of the modes (i.e., those at 2.6 cps and 7.2 cps) were local in character and only involved a few members. Another two of the modes (12.7 cps and 18.1 cps) were shear beam response modes of the crane wall about its weak and strong axes, respectively. The remainder of the modes involved torsional deformation of the steel structure on the annulus region. These modes involved rotation of the steel about the vertical axes.

The NEWMARK 7.5 M Hosgri Record was next used as input in both the east-west (X in the model) and north-south (Z in the model) direction. Structural damping was taken to be 7%. For each of the inputs, response spectra were generated for all nodes in the annulus steel in each direction. Equipment damping was taken to be 2%.

The following procedure was used to generate the envelope spectra. The X input and Z input disturbance each caused X and Z direction spectra at a node. The X spectra caused by X input was combined by the square root of the sum of the squares (SRSS) with the X spectra caused by the Z input. This was done for all nodes on the floor. At each spectral frequency the peak accelerations of all of the nodes were plotted as the envelope value. The same procedure was then used for obtaining the Z envelope.

From the analysis results, it was concluded that the peak spectral values on the crane wall were significantly lower than those on the annulus steel. This clearly indicates that the flexibility of the annulus steel was important. It was also concluded that input in one direction caused a significant response in the other direction. This comes about because of the torsional modes in the annulus steel. The work was completed by the end of January 1983, and the results were presented during an open meeting at NRC on February 15, 1983.

3.6.5 Analysis of Containment Spray Discharge Line and Accumulator Loop

Finite element models were independently developed and used to determine the natural frequencies for two piping problems at the Diablo Canyon Unit 1. The problem evaluations were:

(1) containment spray discharge line 265-8 (PG&E Problem No. 8-118)

(2) accumulator loop 4 (PG&E Problem Nos. 6-4 and 6-7)

The development of the finite element model was based on the information and drawings included in the document package for each problem provided by PG&E. The analyses were performed using the BNL-developed PSAFE2 computer code and the BNL updated version of the SAP V computer code. For both problems some deficiencies and omissions were noted in the PG&E-Westinghouse models. These were:

Containment spray discharge line (Problem No. 8-118)

(1) span length difference of 3 ft noted between nodes 85 and 95 (BNL span larger)

(2) span length differences of the order of 0.3 ft noted in vicinity of nodes 85, 125, 205, and 270 (BNL spans larger)

(3) the X coordinates of nodes 90 and 93, supports 98/4R and 55S/162R, undefined; PG&E computer listing used

(4) support 55S/162R not shown.

Accumulator loop (Problem Nos. 6-4 and 6-7)

(1) The definition of the bend defined by nodes 425 and 426 (5D bend, 6° angle) on DWG 437985 are inconsistent with pressurizer (1-4) centerline and accumulator (1-4) centerline locations shown on the same drawing. Westinghouse computer listing data (LR elbow, 16° angle) are consistent and were used.

(2) The vertical dimensions of the pipe run from nodes 4200 to 4006 on DWG 437985 are inconsistent. Westinghouse computer listing was used.

(3) Modeling differences noted were:

  (a) connectivity in vicinity of valve 8948-D adjusted to correspond to drawing

  (b) location of node 4462 adjusted to reflect 3½-in. lateral offset of valve 8808-D CG

  (c) line of action of supports 12-99SL, 12-98SL, 13-27SL, 13-30SL, 13-31SL, and 56N-49R adjusted to correspond to support drawings; angular changes of up to 10° required

  (d) stiffness of support 58N-60R increased from 4.17×10^5 to 4.17×10^7 to conform with PG&E submittal

  (e) wall thickness of valve 1-8818-D modeled as 2.154 in. (3t).

(4) insulation specification for line 1/S6/3847/6SPL from valve 1-8818-D to 8 x 6 reducer (node 33) undefined; Westinghouse computer listing used

(5) insulation specification for lines 1/S1/1297/10 and 1/S6/256/10 undefined; Westinghouse computer listing used

(6) elbow designations not shown; Westinghouse computer listing used

The natural frequencies predicted using the BNL models were found to differ somewhat from the PG&E-Westinghouse estimates. For Problem No. 8-118 a maximum difference of 7% was noted with the BNL frequency estimate being lower. For Problem Nos. 6-4 and 6-7 the maximum difference was 5.6%. These differences are felt to be due primarily to the differences in modeling noted above. The significance of these differences was not further investigated as the level of agreement was judged acceptable.

3.6.6 Seismic and Stress Analysis of Buried Diesel Tanks

The work carried out under this task can be subdivided into the following three categories:

(1) Review soil-structure interaction (SSI) models used by Harding and Lawson Associates for the 1978 and 1982 seismic evaluations.

(2) Develop SSI computer models and calculate stresses and safety factors.

(3) Construct refined models and perform SSI seismic evaluations.

A description of each of the above items is given below:

(1) The work carried out by Harding and Lawson on the seismic evaluation of the buried tanks was reviewed. Specifically this review included

   (a) the Harding and Lawson results reported in the seismic part of the 1978 report

   (b) the Harding and Lawson 1982 reanalysis described in a letter report to PG&E dated October 11, 1982

   The objective for reviewing the 1978 work was to identify data (i.e., soil properties, damping values, etc.) needed for the subsequent BNL evaluations The dynamic response of the tanks resulting from the Newmark-Hosgri event was reviewed on the basis of the 1982 reanalysis results. A lumped-mass model was constructed with the fluid modeled as lumped masses rather than finite elements. The objective for developing this model was to obtain a quantitative appreciation of the effect of the fluid on the seismic response of the tank. Seismic responses were obtained with the BNL lumped-mass model and compared with the results from the Harding and Lawson 1982 reanalysis. From this comparison it was concluded that the results obtained by Harding and Lawson differed significantly from the corresponding results obtained by BNL with the lumped-mass model. BNL concluded that this difference could not be justified on the basis of the sloshing effect alone, which was not included in the lumped-mass model. The sloshing effect usually would be expected to alter the response by 10-20%. Sloshing frequencies were calculated and found to be very low, i.e., 0.1 Hz. As such, they should not have important effects on the response of the tank. In view of this, BNL concluded that the significant differences between the Harding and Lawson model and the lumped-mass model constructed by BNL were due to the fluid elements used in the Harding and Lawson model.

   Specifically, as a result of the finite element discretization used by Harding and Lawson, the fluid was not allowed to perform its natural motion. Results from a finer grid confirmed this BNL finding.

(2) The subtasks completed under the second work category are

   (a) BNL FLUSH model development
   (b) deconvolution studies
   (c) soil-structure interaction response evaluations
   (d) evaluation of stresses and safety factors

BNL carried out a response evaluation of the soil-tank system normal to the tank axis (transverse response). BNL constructed the model for inside the trench in a similar fashion to the one used by Harding and Lawson (Z-Z section) for the 1982 reanalysis. The major difference, however, was that the mass of the oil was lumped at the walls of the tank. This approach, although somewhat conservative, was found to be more appropriate than that of the fluid element idealization used in the 1982 reanalysis model by Harding and Lawson. Furthermore, in the BNL model, the transmitting boundaries were moved further away from the tank walls. This was done to avoid possible reflections at the boundaries.

Before performing any response evaluations with this model, deconvolution studies were undertaken. The Newmark-Hosgri acceleration pulse was used at the surface, and by deconvolution the input at the base of the soil-tank system was obtained. For the deconvolution studies the SLAVE code was used. Results from the SLAVE code were compared with those obtained from the FLUSH code. The two results matched quite well.

Using the FLUSH model and the deconvolution results described above, the response of the tank was evaluated by means of soil-structure interaction analysis. Frequencies up to 30 Hz were included. Horizontal and vertical evaluations were carried out. In these evaluations, the Newmark-Hosgri acceleration time history was applied directly at the base of the soil-tank system. In addition to these evaluations, analyses were made using the acceleration time history obtained from the deconvolution. Because of the nonlinearity of the problem, five iterations were performed in all evaluations (i.e., horizontal-vertical and with-without deconvolution).

The results of the soil-structure interaction evaluations were moments and axial and shear forces associated with the beam elements representing the tank walls. Based on these results, a stress evaluation was carried out. The seismic stresses obtained by BNL were then combined with the static stresses given by Harding and Lawson in their 1982 static reanalysis. Based on the total stresses (i.e., static and dynamic), safety factors were computed. In evaluating the safety factors the same approach as that used in the HLA 1982 reanalysis was employed.

(3) In response to comments at a meeting with the staff, PG&E, and the IDVP on June 17, 1983, BNL carried out some further investigations which included the following subtasks:

   (a) development of a BNL refined FLUSH model
   (b) code modification to include fluid elements
   (c) soil-structure interaction evaluations using the BNL refined model
   (d) evaluation of a partially filled case

The BNL refined FLUSH model was essentially constructed from the Harding and Lawson 1982 reanalysis model. The finite element grid of the fluid was, however, substantially refined. Two types of soil properties were assigned to the model. These are the ZZ and YY section properties.

As mentioned, the FLUSH code was modified to include a fluid element. Other modifications were also made to obtain stress response waveforms for the fluid element. This permitted the evaluation of the so-called "tensile stresses" in the fluid elements. Computer runs were made with values of 0.4999 as well as with fluid elements.

Soil-structure interaction evaluations were performed in the horizontal direction only. These were felt to be sufficient with regard to the modeling problem associated with the Harding and Lawson 1982 analysis model. Two sets of runs were made using the ZZ and YY section soil properties. From the results obtained it was clear that the refined-model results were closer to the corresponding lumped-model results. It was also shown that the Harding and Lawson 1982 model differ significantly from both the refined and the lumped model. Furthermore, the responses from the YY model indicated that this model is more critical than the ZZ model. From very limited investigation, BNL also suggested that even higher response would result if YY section properties were to be used together with deconvolution. Finally, initial BNL computer runs made with partially filled tanks also resulted in higher response values. In these initial studies, a partially filled tank was simulated by assigning very low stiffness values to the top fluid layer so that it approximated a 90% filled case. For such a case, the bending stresses, particularly at the top portion of the tank, increased. The reason for this is that because of the upward motion of the fluid inside the tank there is less fluid resistance to the tank deformations.

In view of the BNL results, PG&E committed to perform the following further investigations:

(1) Refined mesh computer runs will be made using YY section properties.

(2) Runs with and without deconvolution will be made.

(3) A partially filled tank case will be examined.

(4) YY section properties in conjunction with the static analysis will be carefully examined.

4 NONSEISMIC DESIGN VERIFICATION EFFORT

4.1 Introduction

This section presents the staff evaluation of the verification of nonseismic design aspects of safety-related systems performed by the IDVP in accordance with the NRC letter of November 19, 1981 (Phase II of the IDVP).

The following three safety-related systems were selected as the sample for verification of the analysis and design work performed by PG&E and service-related contractors:

(1) auxiliary feedwater system (AFWS)
(2) control room ventilation and pressurization system (CRVPS)
(3) 4160-V electrical distribution system (safety-related portion only)

The effort is described in various Interim Technical Reports (ITRs), in Sections 4.7 and 4.8 of the IDVP Final Report, and in the PG&E Phase II Final Report.

The three systems were selected because the design involved interactions and information flow among different organizations within PG&E and with their service contractors, it involved interrelationships and applicability of several design criteria, and it covered a broad spectrum of system functions and purpose (i.e., water, air, and electrical system function).

The IDVP review included the development of the chain for the design and analyses for the systems, i.e., identification of PG&E organizations and service contractors, the review of PG&E calculations for design process verification, and the performance of independent calculations. The verification effort for the AFWS and CRVPS included the mechanical and nuclear design aspects, the instrumentation and control system and electrical power supply system, consideration of the effects of line breaks inside and outside containment, equipment environmental calculations and qualifications, and fire protection aspects. The 4160-V electrical distribution system was reviewed with respect to its functional requirements and specifications and with respect to fire protection. The staff review and evaluation of the IDVP effort for the three systems of the initial sample is presented in Section 4.2.

To begin the review the IDVP requested and PG&E provided information regarding design inputs, methodology, calculations, outputs, licensing criteria, and commitments, as appropriate. The IDVP reviewed the information in these areas. As the review progressed and concerns were identified and categorized by the IDVP, PG&E responded by providing additional documentation, recalculation, and analyses, or committed to appropriate changes as necessary to resolve the matters of concern. The IDVP verified the acceptability of the design of proposed modifications or reanalysis, including review of applicable calculations. The results of the IDVP review and evaluations were documented in ITRs, each of which dealt with a specific design aspect under review. The ITRs were revised as additional information and resolution of open items were obtained.

As a result of the IDVP verification effort for the three systems in the initial sample, the IDVP identified four areas for additional generic evaluation as the concerns involved requirements and design approaches applicable to other safety-related systems. These areas were:

(1) redundancy of equipment and power supplies in shared safety-related systems

(2) selection of system design pressure, temperature, and differential pressure across valves

(3) environmental consequences of postulated pipe breaks outside containment

(4) circuit separation and single failure capability for safety-related electrical components

As a result of the quality assurance verification effort discussed in Section 2, one additional generic evaluation was performed.

(5) jet impingement effects resulting from postulated pipe breaks inside containment

The IDVP review methodology of the additional verification was comparable to that of the initial sample. Acceptance criteria are the same as indicated previously. The design verification for the additional verification is discussed in Section 4.3.

On the basis of the above considerations, the staff concludes that the IDVP review adequately considered the design approach and philosophy for implementing licensing criteria and commitments employed by the applicant for safety-related systems in accordance with the scope of the Phase II program. Details of the verification review, results, corrective actions, and staff conclusions for each review area are provided in Sections 4.2 and 4.3.

4.2 Initial Sample

4.2.1 Verification of Mechanical/Nuclear Design

4.2.1.1 Auxiliary Feedwater System

To verify the adequacy of the mechanical/nuclear design of the auxiliary feedwater system (AFWS), the IDVP reviewed the system's redundancy, hydraulic design, design pressure and temperature, and field installation and the Technical Specifications and regulatory requirements pertaining to the system.

The IDVP review of AFWS Technical Specifications consisted of comparing the AFWS design to the Technical Specification requirements, including the AFWS water supplies, pump performance, area temperature limits and power supply, and load timer setpoints. The IDVP performed an independent calculation that confirmed that the condensate storage tank (primary AFWS water supply) capacity met the Westinghouse and Technical Specification criteria. The IDVP compared AFWS flow requirements to the auxiliary feedwater (AFW) pump vendor performance information and determined that the pumps can be tested in accordance with the Technical Specification requirements. However, a concern was identified in EOI 8015 by the IDVP regarding the fact that AFWS Technical Specifications did not require measurement of AFW pump flow during testing. The PG&E response indicated that the staff had approved the AFWS Technical Specifications without this requirement and thus the licensing commitment was met. The IDVP agreed with the resolution. The staff also concurs with the resolution. Because pump discharge pressure is measured and is considered an adequate indication of pump performance, the review of area temperature monitoring for AFWS equipment verified that appropriate instrumentation is provided for ensuring conformance with area temperature limit Technical Specifications. In addition, a review of the design for the electrical and control circuits for the power supply and load timer as well as the minimum time for AFWS operation confirmed compliance with the Technical Specifications.

The IDVP reviewed the AFWS drawings and postulated various single failures with concurrent loss of offsite power and confirmed that the licensing criteria concerning redundancy in the AFWS are met for ensuring the system's safety function.

The IDVP modeled the hydraulics of the AFWS independently with a computer program using the latest PG&E documentation. The computer program compared favorably with actual test data. Calculated AFWS flow rates and available net positive suction head were verified to meet the values indicated in the Final Safety Analysis Report (FSAR) and the values specified by the vendor. A review of piping drawings as compared with piping schematics resulted in only minor discrepancies which have no affect on the hydraulic analysis, safety, or licensing commitments. The characteristics of the motor- and turbine-driven pumps were verified to comply with vendor and FSAR requirements. The review of AFWS initiation and diesel generator loading logic diagrams verified that full system flow will be available within the time committed to in the FSAR and that steam generator blowdown and sampling line isolation valves receive a closure signal on AFWS start.

The computer hydraulic analysis was performed with the AFWS runout control setpoints and indicated that less than minimum required flow may be provided under certain conditions. The concern involved the design of the flow limiting control scheme for preventing motor-driven AFW pump runout when a steam generator is depressurized (EOI 8060). Specifically, the steam generator level control valves in the AFW supply lines that normally respond to steam generator level are also required by the runout control system to respond to low pump discharge pressure. These valves will close when the low pump discharge pressure setpoint is reached. Thus, conflicting level and pressure control signals may at times result in the valves being directed to perform opposite functions simultaneously. The analysis indicated that the pressure control setpoints may not be low enough to permit minimum required flow to the steam generators when only one motor-driven AFW pump is operating. In response to this concern, PG&E changed the low pump discharge pressure setpoints and committed to perform a startup test of the runout control system to confirm dynamic stability. The IDVP review of the new setpoints and startup test commitment indicated that the proposed resolution was acceptable. The staff concurs with this resolution.

The IDVP review of the AFWS design pressure for piping and components consisted of independent calculations that determined that applicable codes requiring that the system be designed for the most severe operating condition were not met. System design pressures were determined to be exceeded in various operating modes including low flow and recirculation (EOI 8009). Static head and pressure surges also were not properly accounted for in the design. In response, PG&E recalculated system design pressure, lowered the AFW turbine overspeed trip setpoint, and committed to replace system components that are rated below the new design pressure. The IDVP performed independent calculations that confirmed that the new design pressure is code acceptable. A review of the manufacturer's data for system components against the new pressure indicated that 42 valves required replacement. The IDVP field-verified that the modifications were made. The staff concurs with this resolution.

The IDVP review of the protection of low-pressure portions of the AFWS from high-pressure portions indicated that the applicable design code was not met. The specific concern involved a throttle valve in the AFW pump turbine bearing cooling line which acts as a high- to low-pressure division valve, but pressure protection is not provided downstream as required by the applicable code (EOI 8010). High AFWS discharge pressure can occur in a number of operating modes including system operation with suction supply from the reservoir (backup water source), turbine overspeed, recirculation, low flow, and inadvertent valve operation. In response, PG&E modified the turbine-driven pump recirculation line configuration to reduce the discharge pressure. The IDVP verified that the modification is code acceptable and field-verified the installation. The staff concurs with this resolution.

The IDVP review of valve actuator sizing determined that maximum differential pressure was not specified for ensuring valve operability in all cases. The specific concern was with the actuators for the flow control valves and header valve on the steam supply to the turbine-driven AFW pump (EOI 8062). In response, PG&E modified the gear ratio on the steam supply header valve actuator in accordance with the manufacturer's recommendations. The IDVP reviewed the documentation and verified completion of this modification. The IDVP verified that the flow control valves did not require modification as they were not required to operate for safe shutdown since adequate redundancy is available for ensuring safety functions during a steamline break event. The staff concurs with the above resolution.

Verification of system temperature design determined that acceptable temperature conditions were incorporated. In addition, the AFW pump suction line from the condensate storage tank was determined not to be susceptible to freezing on the basis of its location and site temperature data.

The above concerns regarding system design pressure determination, protection of low-/high-pressure interconnections, and valve actuator differential pressure specification were determined by the IDVP to have generic consequences, and thus required further verification. The results of that additional verification are discussed in Section 4.3.2.

The IDVP reviewed PG&E correspondence with the staff to verify compliance with licensing commitments including those made in response to the TMI accident .

backfit requirements (NUREG-0737, Item II.E.1.1). Additionally, the review confirmed that all commitments regarding the AFWS have been implemented.

The IDVP concluded its AFWS review with a field walkdown to verify compliance of the as-built installation with the design documents. The as-built installation was confirmed to meet design drawings except that (1) a steam trap on the turbine-driven AFW pump steam supply line was not provided and (2) there were discrepancies in the arrangement of the long-term cooling water supply line (EOIs 8027 and 8048, respectively). In response to the steam trap discrepancy, PG&E indicated that the design drawings would be revised to delete the steam trap on the steam supply line because satisfactory testing of the turbine-driven pump was completed without the need for the trap. Regarding discrepancies in the long-term cooling water supply line, PG&E indicated that drawings were mistakenly revised but that the actual field installation was acceptable and in accordance with previous design changes. The IDVP confirmed that the actual AFWS installation was acceptable and no technical concern existed. The staff concurs with the above resolution.

On the basis of the staff review of the EOI files established as a result of the verification of mechanical/nuclear design of the AFWS and resolution of concerns identified herein, the staff concludes that the IDVP has confirmed that the criteria and licensing commitments regarding the AFWS mechanical/nuclear design have been satisfied. Further, the staff concludes that prior conclusions as stated in the Safety Evaluation Report (SER) for Diablo Canyon Unit 1 are not altered. Discussion of the additional verification of the generic concern identified regarding selection of design pressure and temperature and differential pressure across power-operated valves is contained in Section 4.3.2.

4.2.1.2 Control Room Ventilation and Pressurization System

To verify the adequacy of the mechanical/nuclear design of the control room ventilation and pressurization system (CRVPS), the IDVP reviewed the system cooling load; air flow rates; applicable codes, standards, and regulatory guides; design temperatures and pressures; control room habitability; Technical Specifications; redundancy; and field installation.

The IDVP review of the CRVPS cooling capability consisted of an independent cooling load calculation for the four design operating modes based on actual vendor and nameplate data for equipment heat rejection into the control room and outside air conditions as identified in the FSAR. The results of this calculation were compared to the capacity of the CRVPS cooling equipment. It was determined that the IDVP calculated results were comparable to the PG&E values and the calculated cooling load is within the nameplate rating of the equipment.

The IDVP review of CRVPS air flow rates consisted of an examination of test reports and startup test results. Recorded air flow rates were within acceptable limits when compared with the assumed design values. The actual air flow rates were used in the above-mentioned independent calculation for verifying that the design control room temperature and the calculated temperature were below the maximum allowable design value. An examination of fan brake horsepower against the fan motor nameplate ratings indicated that this equipment was adequate to accommodate system design air flows. The review of the startup test results verified the capability of the system to maintain the assumed design positive pressure.

The IDVP review confirmed that applicable codes, standards, and regulatory guides as identified in the FSAR were included in the CRVPS equipment purchase specifications. Further, review of the CRVPS equipment specifications verified that the designs of the duct, fan, refrigerant equipment, piping, and valves are within the specific design temperature and pressure limits and are adequate for the actual recorded test conditions. A review of the plant Technical Specifications for the CRPVS confirmed that they satisfied the guidelines of Regulatory Guide 1.52 and the FSAR commitments. In addition, a walkdown of the system confirmed that the as-built configuration agreed with the design drawings used in the IDVP review.

The IDVP review of control room habitability included examination of the radiation dose calculation and chlorine concentration calculation to verify that correct inputs (i.e., damper closure time, air flow rates, control room volume, filter efficiencies, detector response time, and infiltration rate), including an assumed single failure, were used. It was determined that the radiation dose calculation agreed with the FSAR commitments. However, differences were noted in some of the inputs to the chlorine concentration calculation when compared with those in the FSAR. Therefore, an independent calculation was performed using actual test data and newly calculated values for damper closing time and chlorine detector response time. The calculated results were within the limits of Regulatory Guide 1.52. Further, the IDVP verified that the specified sensitivities and response times for the chlorine and radiation monitors agreed with the FSAR commitments, and a field walkdown confirmed that these monitors were properly located in the air intakes. The purchase specifications for the high-efficiency particulate air/charcoal filter units were reviewed to verify that specified filter efficiencies and air flow capacities agreed with the FSAR habitibility analysis and actual test results. Satisfactory results were obtained and compliance with Regulatory Guide 1.52 was shown.

The IDVP review of the CRVPS flow diagram and duct drawings verified that redundant equipment was incorporated in the system design. However, the review of the CRVPS electrical power supply design raised two concerns as to whether adequate power supply redundancy is provided to meet the single failure criterion as indicated in the FSAR because of the power supply sharing design between Unit 1 and Unit 2. The first concern is that portions of the CRVPS that are required to maintain Unit 1 control room habitability that are shared between Units 1 and 2 are provided power from the Unit 2 vital power supplies. Therefore, with Unit 2 not available during long-term outages, system power supply redundancy is not provided. Further, Unit 1 Technical Specifications permit plant power operation with only Unit 1 vital electrical buses available (EOI 8012). The second concern is that portions of the CRVPS that are shared between Units 1 and 2 are provided power from both Unit 1 and 2 vital buses. Under the design-basis case of a postulated loss-of-coolant accident (LOCA) in one unit and emergency shutdown of the other, the licensing commitment required assuming a simultaneous single failure in a vital bus in each unit. Because the swing diesel generator would be aligned to the LOCA unit, the IDVP determined that inadequate power supply redundancy is available to meet the single failure criterion for ensuring the CRVPS habitability and equipment cooling safety functions (EOI 8016).

PG&E provided resolution of the above concerns by modifying the CRVPS power supply design to include power to each equipment train from both a Unit 1 and Unit 2 power supply with redundant trains powered from different vital buses. The IDVP performed an independent failure mode and effects analysis which verified the acceptability of the new design against the single failure criterion. However, because other systems at Diablo Canyon may share power supplies, a generic evaluation and additional verification in this review area was undertaken by the IDVP. This concern is discussed further in Section 4.3.1. The staff concurs with the above specific resolution for the CRVPS.

On the basis of the staff review of the EOI files established as a result of the verification of the mechanical/nuclear design of the CRVPS and the resolution of concerns identified, the staff concludes that the IDVP has confirmed that the criteria and licensing commitments for the design of the CRVPS have been satisfied. Further, the staff concludes that the prior conclusions as stated in the SER for Diablo Canyon Unit 1 are not altered. Discussion of additional verification of the generic concern identified with respect to redundancy of power in shared safety-related systems is provided in Section 4.3.1.

4.2.2 Electrical Design

The safety-related electric design for the AFWS, CRVPS, and 4160-V distribution system was selected for review by the IDVP. The purpose of the review was to verify that the selected safety-related electric system designs satisfy the commitments and design criteria specified in the licensing documents for Diablo Canyon Unit 1. Based on the IDVP review and verification, the staff concludes that the safety-related electrical design for the above systems meets the requirements of General Design Criterion (GDC) 17 of Appendix A to Part 50 of Title 10 of the Code of Federal Regulations (10 CFR 50) with respect to (1) capacity and capability of onsite and offsite power systems to permit functioning of structures, systems, and components important to safety and (2) the independence and redundancy requirements of onsite power systems to perform their safety function assuming a single failure. In addition, the staff concludes that the design meets the requirements of GDC 4 with respect to compatibility of electric equipment and components with the harsh environmental conditions associated with postulated accidents and meets the requirements of 10 CFR 50.49.

4.2.2.1 Auxiliary Feedwater System

The IDVP review of the electrical design for the AFWS is reported in ITR 25 and Section 4.7.2.2 of the IDVP Final Report. The review included AFWS electrical equipment and its interconnection with the electrical distribution system. The major elements reviewed were (1) the capacity and capability of the electric distribution system to supply the required power, (2) the capability of electrical equipment, (3) the independence and redundancy of electrical power sources and their associated circuits, and (4) the qualification of electrical equipment and its circuits for harsh environments.

Eleven areas of concern were identified by the IDVP during the review of the electrical design of the AFWS, each identified by its unique EOI file number. They are summarized in Section 5 of ITR 25 and ITR 27. In regard to 10 of the concerns (EOIs 8011, 8042, 8043, 8044, 8059, 8055, 8059, 8061, 8063, and 8064), 8059 PG&E provided to the IDVP additional information, proposed changes to licensing documents, or reanalysis. PG&E committed to revise FSAR Section 8.3.3 to reflect acceptability of as-built conditions regarding separation (EOI 8055) and color coding (EOI 8059). Based on the IDVP review and evaluation, the staff concludes that these concerns have been acceptably resolved and that plant modifications or additional verification is not required. The remaining concern (EOI 8057) addresses independence of redundant electric power system components. This concern is evaluated below with similar concerns identified by the IDVP in its review of the CRVPS.

4.2.2.2 Control Room Ventilation and Pressurization System

The IDVP review of the electrical design for the CRVPS is reported in ITR 26 and Section 4.7.3.2 of the IDVP Final Report. The review included CRVPS electrical equipment and interconnections with the electrical distribution system. The major elements reviewed were (1) the capacity and capability of the electric distribution system to supply the required power, (2) the capability of electrical equipment, (3) the independence and redundancy of electrical power sources and their associated circuits, and (4) the qualification of electrical equipment and their circuits for harsh environments.

Eleven areas of concern were identified by the IDVP during the review of the electrical design of the CRVPS, each identified by a unique EOI file number. They are summarized in Section 5 of ITRs 20, 26, and 28.

Concerns, identified by EOIs 8011, 8042, 8044, 8059, and 8061, are the same concerns identified and evaluated in Section 4.2.2.1 for the AFWS. Based on the IDVP review, the staff concludes that each of these concerns has been acceptably resolved and that plant modifications or additional verification is not required.

The concerns raised in EOIs 8012, 8016, and 8046 address redundancy of components or sharing of components between Unit 1 and Unit 2. These concerns are evaluated with the mechanical/nuclear design of the CRVPS in Section 4.2.1.

The remaining concerns (EOIs 8017, 8041, and 8057) address independence of redundant safety-related components and compliance with the requirements of GDC 17. The concern in EOI 8017 was raised by the IDVP because redundant control power sources are interconnected through a single control switch. The IDVP concern was that a single failure may cause loss of power to redundant divisions of safety-related systems. PG&E stated that modifications would be made to resolve the concern. This EOI resulted in a generic concern regarding single failures, which is discussed in Section 4.3.4, including the modifications that were made. Based on the IDVP review, the staff concludes that the modifications are acceptable. The staff evaluation of the resulting generic concern is presented in Section 4.3.4.

The concern in EOI 8041 was raised by the IDVP because redundant electric power divisions or trains were electrically interconnected through two circuit breakers and a single power transfer switch. The IDVP concern was that a single failure may cause loss of redundant power divisions. PG&E issued an operating order to document their standard practice for keeping open the circuit breaker used for supplying an alternate power source. The IDVP concluded that this practice satisfies the independence and single failure requirement. Based on the IDVP review, the staff concludes that this concern has been acceptably resolved and that plant modifications or additional verification is not required.

The concern in EOI 8057 was raised by the IDVP because control cables located in panels were not separated in accordance with licensing commitments. The IDVP concern was that a single failure may cause loss of redundant divisions of safety-related systems. PG&G informed the IDVP that a complete review of all safety-related circuits would be conducted and that modifications would be made as required to meet the Diablo Canyon licensing commitments. This EOI resulted in a generic concern regarding circuit separation, which is discussed in Section 4.3.4. The staff evaluation of the resulting generic concern is presented in Section 4.3.4. Based on the IDVP review, the staff concludes that the modifications are acceptable.

4.2.2.3 4160-V Distribution System

The IDVP review of the electrical design for the 4160-V distribution system is reported in ITR 24 and Section 4.7.4 of the IDVP Final Report. The review included the 4160-V safety-related buses and their interconnection with offsite and onsite power sources and lower voltage distribution system buses. The major elements reviewed were (1) the capacity and capability of the offsite and onsite power sources to supply the required voltage and frequency to the 4160-V buses, (2) the capacity and capability of 4160-V circuit protective devices, and (3) the independence and redundancy of the onsite power sources and power circuits between the onsite power source and the 4160-V buses.

Seven areas of concern were identified by the IDVP during the review of the 4160-V distribution system, each identified by its unique EOI file number. They are summarized in Section 5 of ITR 24.

In regard to three of the concerns (EOIs 8013, 8022, and 8045), PG&E provided to the IDVP additional information or analysis which resolved the concerns. Based on the IDVP review and evaluation, the staff concludes that these concerns have been acceptably resolved and that plant modifications or additional verification is not required.

The remaining concerns (EOIs 8023, 8024, 8025, and 8026) address the capability of the offsite power sources to supply adequate voltage to the 4160-V distribution system and to safety loads. PG&E changed voltage tap settings on the offsite power system 230-kV startup transformer and provided to the IDVP an analysis based on the new tap setting. Based on the IDVP review, the staff concludes that each of these concerns has been acceptably resolved and that plant modifications or additional verification is not required.

4.2.3 Instrumentation and Controls Design

A review was performed for the safety-related instrumentation and controls for the auxiliary feedwater system (AFWS) and control room ventilation and pressurization system (CRVPS). The review covered three major areas: (1) environmental qualification, (2) system design conformance to licensing requirements, and (3) field verification of installed systems.

The design and installation of safety-related instrumentation and controls for the AFWS and CRVPS were reviewed to confirm compliance with the licensing commitments for these systems. The licensing documents include the FSAR, PG&E letters to NRC on licensing criteria and responses to questions, and design documents including logic diagrams, instrument and electrical schematics, and wiring diagrams.

4.2.3.1 Auxiliary Feedwater System

Concerns identified in the review of the AFWS were addressed in Interim Technical Report (ITR) 27, Rev. 1. The concerns raised by the IDVP and the method of resolution are discussed below.

In EOI 8018 the concern was raised that valve operators for the isolation valves which provide the steam supply to the turbine-driven auxiliary feed pump from two of the four main steam generator headers were not classified and procured as safety-related components. The basis for this concern was that these valves may not be operable in a harsh environment associated with a steamline break in the steam supply line to the turbine-driven pump and, therefore, would not be capable of being closed to mitigate the consequences of such an event. PG&E provided to the IDVP an analysis performed by Westinghouse indicating that the steam flow from the postulated break would not trip the unit when operating at power levels of 10, 30, 60, or 100%. It was noted that, according to FSAR Appendix 3.6, the assumption of loss of offsite power need not be considered as a consequence of this event because this event does not result in a unit trip. Thus, the normal feedwater system would be assumed to be available. Westinghouse stated that for this case the blowdown of the two steam generators would be acceptable as long as the other two were intact. The IDVP concluded that while it is desirable to isolate the break, the licensing commitment to maintain safe shutdown capability was shown by the analysis. Further, the IDVP considered this to be adequate in that feedwater flow to the steam generators can be maintained to mitigate the effects of a steamline break and these valves are not required to perform a safety function. On this basis the file was closed.

The staff has reviewed the disposition of this concern and has found that the subject valves are identified as containment isolation valves in Section 6.2.4 of the FSAR and are to be in conformance with the requirements of GDC 57 of Appendix A to 10 CFR 50 as manual isolation valves for closed systems penetrating reactor containment. Because the control circuits for these valves are classified as not safety related, the staff asked both the IDVP and PG&E if this had been considered in view of the requirements for containment isolation. By letter dated July 26, 1983, the IDVP noted that its review was limited to consideration of the valve function with respect to the AFWS and licensing commitments to maintain safe shutdown capability. Since an unresolved issue had not been identified with these valves, the IDVP did not expand its review to consider other functions such as containment isolation. Therefore, the staff concludes that the conclusions of the IDVP were appropriate and consistent with the scope of the review identified in the program management plan for IDVP. PG&E, by letter dated July 27, 1983, provided their justification for classifying the control circuits for these valves as not safety related, and noted that these circuits were procured and installed as Class 1E components. The staff requires, consistent with GDC 57, that these circuits be classified as safety-related and that PG&E should indicate their conformance to this requirement.

In EOI 8032 the concern was raised that a fire in the main control room may cause damage that could preclude transfer of the control of the level control valves from the control room to the hot shutdown panel. These control valves are used to control steam generator level by regulating the auxiliary feedwater (AFW) flow supplied by the motor-driven AFW pumps. The basis for the concern was a commitment by PG&E, made in response to previous NRC fire protection questions, that the control of these valves could be achieved from the hot shutdown panel in the event of a fire in the main control room. Inherent in this commitment is the implication that fire damage would not preclude the transfer of these controls and that subsequently the control of steam generator level could be carried out at the hot shutdown panel by having had made this transfer. PG&E stated that this concern did not in itself create a safety significant issue and noted that the level control valves could be operated manually. Further, such action had been described as an action that would be taken in the event of a fire at the remote shutdown panel. However, PG&E committed to make modifications to eliminate this concern. The IDVP has verified the implementation of these modifications and has found them acceptable. Based on this action the item was closed. The staff concurs with the IDVP resolution of this matter.

In EOI 8047 the concern was raised that a single failure of an auxiliary relay would prevent automatic closure of the redundant steam generator blowdown isolation valves on automatic initiation of the AFWS. The basis for this concern was that sufficient decay heat removal may not be provided under limiting conditions postulated for accidents if steam generator blowdown is not terminated. PG&E concurred that the single relay identified is not safety related; however, PG&E noted that steam generator blowdown is terminated by safety-related signals, namely safety injection and/or Phase A containment isolation, thereby preventing the loss of steam generator inventory for all but two accident cases addressed in Chapter 15 of the FSAR. The two cases under which steam generator blowdown would not be terminated by safety-related signals are loss of normal feedwater and loss of offsite power. In its investigation of this matter, the IDVP reviewed the Westinghouse analyses, included in correspondence from PG&E to the NRC, on the adequacy of the AFWS design to provide sufficient flow consistent with the FSAR safety analysis. These analyses performed by Westinghouse included the assumption that steam generator blowdown flow is terminated for loss of main feedwater or offsite power. Therefore, to resolve the conflict that steam generator blowdown may not be terminated for these events (i.e., the failure of the single relay which initiates this action), PG&E provided documentation to the IDVP indicating that for these events where blowdown is not terminated, adequate feedwater or AFW flow exists assuming the loss of one AFW train. On this basis the IDVP determined that there is no violation of licensing commitments.

Although the staff does not take issue with the PG&E conclusion that adequate AFW flow will be available for safe shutdown, it does find that the use of a single relay to isolate steam generator blowdown on automatic initiation of the AFWS is in conflict with the design shown in FSAR Figure 7.2-1, Sheet 15. Further, the redundancy as shown by this figure, which is typical for all Westinghouse plants, is consistent with the Westinghouse analysis noted above which assumes that steam generator blowdown is terminated for those events not associated with safety injection. The staff concludes that the concern identified does represent a deviation from the Westinghouse interface requirements to be implemented by the balance-of-plant design. Therefore, the staff concludes that the IDVP did not fully consider this aspect of commitment for the design. The staff will pursue this concern with PG&E to obtain a resolution of this matter.

In EOI 8051 the concern was raised that the pressure transmitter on the discharge of the turbine-driven auxiliary feed pump is not powered from a safety-related power source. The basis for this concern was that FSAR Appendix 3.6 identified this transmitter as essential equipment. PG&E responded to this concern by stating that this transmitter performs no safety-related function and that the FSAR would be revised to reflect this fact. The IDVP concluded that this action resolved this concern and classified this item as a deviation. The staff concurs with the conclusions of the IDVP on this matter.

In EOI 8052 the concern was raised that flow transmitter FT-78 and flow control valve FCV-95 in the AFWS may not be environmentally qualified for harsh environments associated with high energy line breaks. The basis for this concern was that these items were not listed as located in harsh environments in the PG&E environmental qualification report of safety-related components located in harsh environments. PG&E responded to these concerns by noting that the flow transmitter was identified under a different identification number, FT-200. The environmental qualification of this item has not been completed; however, the vendor provided justification for interim operation pending completion of this program. The flow control valve was conditionally qualified, subject to an ongoing maintenance surveillance program, but was erroneously listed as a component not subject to a harsh environment. PG&E will correct errors in the qualification report tables. On the basis of the PG&E response, the IDVP withdrew its concern on this matter. The staff concurs with the IDVP resolution of this matter.

In EOI 8058 the concern was raised that the steam generator level control valves (LCV-110, -111, -113, and -115) may not be environmentally qualified for harsh environments associated with high energy line breaks. The basis for this concern was that the environmental qualification report identified an unqualified motor capacitor as an outstanding item to be completed. The report provided a justification for interim operation with replacement of this component following 20,000 hours of operation. PG&E responded to this concern, noting that an analysis to determine the qualified life of this component is being conducted. The IDVP concluded that the PG&E response resolved this concern. The staff concurs with the conclusions of the IDVP on this matter.

The following EOI files identified in ITR 27 are addressed in other sections of this report as follows: EOIs 8054, 8055, 8057, 8059, and 8064 in Section 4.2.2.1 and EOI 8060 in Section 4.2.1.

On the basis of the staff review of the EOI files established in the IDVP review of the AFW instrumentation and control systems and resolution of concerns identified herein, with the exception of pending actions for EOIs 8018 and 8047, the staff concludes that the IDVP has confirmed that the licensing commitments for the design of this system have been satisfied and that no generic concerns were identified that alter the staff's prior conclusion stated in its SER report for Diablo Canyon Unit 1.

4.2.3.2 Control Room Ventilation and Pressurization System

Concerns identified in the review of the CRVPS were addressed in ITR 28, Rev. 1. The following Error or Open Item (EOI) files were established during this review.

In EOI 8053 the concern was raised that radiation monitors RE-51, -52, -53, and -54 were identified as nonsafety related on the instrument schematic drawing. PG&E provided a response to this concern noting that this identification was a drafting error only and that these instruments were purchased and installed to safety-related requirements. The IDVP concurred with this response and reclassified this item as a deviation. The staff concurs with the IDVP on the resolution of this matter.

In EOI 8056 the concern was raised that portions of the CRVPS were omitted from PG&E's environmental qualification report. The basis of this concern was that some equipment may not be environmentally qualified for normal and abnormal environmental conditions postulated for the location of this equipment. PG&E provided a response indicating that the classification of CRVP components as safety-related electrical equipment located outside containment and not subject to a severe environment did not include some components because the compilation of the listed components was made before the system design was completed. Further, the environmental qualification report will be updated to include the components of the CRVPS that were not listed. The IDVP confirmed that no safety-related components of the CRVPS are subject to harsh environments and that components were designed for expected service conditions. On this basis, the file was reclassified a closed item. The staff concurs with the IDVP resolution of this matter.

The following EOI files identified in ITR 28 are addressed in other sections of this report as follows: EOIs 8017, 8057, and 8059 in Section 4.2.2; EOI 8046 was transferred to EOI 8012 and is addressed in Section 4.2.1.

On the basis of the review of the EOI files established in the IDVP review of the CRVP instrumentation and control systems and resolution of concerns identified herein, the staff concludes that the IDVP confirmed that the licensing commitments for the design of this system have been satisfied and that no generic concerns were identified which alter the staff's prior conclusions stated in its SER.

4.2.4 High Energy Line Break and Internally Generated Missiles

To verify that adequate separation (i.e., distance, barriers, and restraints) exists in the design for protection of the AFWS and CRVPS from the effects of high energy line breaks (pipe whip and fluid jet) and internally generated missiles, the IDVP performed an analysis of potential AFWS and CRVPS targets using the FSAR commitments regarding postulated high energy line break locations and internally generated missile sources outside containment. A field verification of the above analysis results was performed to confirm the acceptability of protection provided.

The above IDVP analysis for high energy line breaks consisted of (1) identifying potential targets (i.e., components) in each system, (2) identifying high energy lines and postulated break locations using the FSAR analysis for the various high energy systems, (3) identifying pipe rupture restraint locations, (4) identifying potential interaction zones between the system components and postulated pipe breaks, and (5) confirming interactions identified by performing a field verification. The field verification consisted of (1) visually confirming the as-built arrangement to the FSAR analysis drawings, (2) confirming location and configuration of pipe rupture restraints, (3) confirming locations of target components, and (4) verifying that proper protection was afforded equipment necessary to ensure the safety functions of the AFWS and CRVPS. The above review resulted in identifying only one concern regarding protection of the AFWS (from jet impingement) and two concerns regarding protection of the CRVPS (from pipe whip).

The concern in the high energy line break analysis for the AFWS was that a conduit providing power to components providing AFW flow could be damaged by jet impingement from a postulated longitudinal high energy line break (EOI 8049). The PG&E response to this item consisted of an additional analysis of the effects of the blowdown thrust force and temperature on the conduit. The revised analysis uses the American Nuclear Society (ANS) Standard 58.2 calculational method for establishing blowdown jet temperature. The IDVP has reviewed this method and verified that it provides acceptable results. The IDVP further confirmed that the conduit is not affected by the jet impingement temperature. The PG&E analysis also confirmed the jet impingement force (pressure) was below the allowable limit for the conduit. Thus, the IDVP verified that the postulated break will not adversely affect the AFWS conduit, and the concern has been satisfactorily resolved. The staff concurs with this resolution.

The concerns in the high energy line break analysis for the CRVPS were that damage to a CRVPS electrical conduit could result from pipe whip from two postulated circumferential pipe breaks (EOIs 8007 and 8008). In response, PG&E provided a reanalysis of the postulated breaks (in the main steam relief valve headers). The response indicated that interpretation of the high energy line break criteria (A. Giambusso letter dated December 18, 1972) does not require postulation of pipe whip in the dead-ended section of the main steam header because insufficient internal energy exists to produce pipe whip because of the limited reservoir. Further, steam blowdown from the opposite end of the postulated break represents an energy source external to the dead-ended header section and, therefore, needs not be considered for pipe whip of the dead-ended section. The above interpretation was applied in designing the existing restraints on the main steam headers. In addition to the above PG&E response, the IDVP performed a further evaluation. The IDVP confirmed that the cables in the conduit in question do not provide power to equipment essential for reactor shutdown under conditions associated with the above postulated main steamline breaks. Therefore, this concern was satisfactorily resolved. The staff concurs with the resolution.

Because only 3 discrete concerns resulted from the high energy line break review of over 700 postulated break locations affecting the 2 systems, a generic concern did not arise, and no additional verification in this area was determined by the IDVP to be necessary. The staff concurs that the small number of discrepancies in the total sample size confirms that further verification was not required.

The above IDVP analysis for internally generated missiles consisted of (1) identifying potential missile sources using the FSAR analysis, (2) identifying AFWS and CRVPS equipment in the postulated missile trajectory, (3) identifying barriers and their relationship to missile trajectories, and (4) determining whether judgments regarding protection provided against potential missile damage were adequate. The above was also confirmed by a field verification. The field verification consisted of visually locating internally generated missile sources, system targets, and barriers (structures or shields).

No concerns related to the protection of the AFWS or CRVPS from internally generated missiles resulted from the above review; thus, no generic concern requiring additional verification in this area was established by the IDVP.

On the basis of the staff's review of the EOI files established as a result of the verification of high energy line breaks and internally generated missiles for the AFWS and CRVPS, and resolution of concerns identified herein, the staff concludes that the IDVP has confirmed that the criteria and licensing commitments regarding protection from the effects of high energy line breaks and internally generated missiles outside containment have been satisfied, and that no generic concerns were identified which alter the staff's prior conclusions as stated in the SER for Diablo Canyon Unit 1.

4.2.5 Effects of High Energy Line Cracks and Moderate Energy Line Breaks

To verify that the effects of postulated high energy line cracks and moderate energy line breaks were properly considered in the design of the AFWS and CRVPS, the IDVP reviewed the PG&E analysis of high energy line crack effects (prepared for PG&E by Nuclear Services Corporation (NSC)) and moderate energy line breaks outside containment against the FSAR licensing commitments specific to the AFWS and CRVPS. In addition, IDVP performed a field inspection of potential AFWS and CRVPS target locations and high energy piping system sources in order to do an independent analysis of high energy pipe crack effects.

The independent analysis examined the blowdown jet from high energy piping sources using the FSAR licensing criteria to determine if a target was hit. The blowdown temperature was calculated using the FSAR methodology. Determinations were made for those targets hit if their failure would adversely affect the CRVPS or AFWS safety functions. The blowdown jet temperature calculation methodology and assumptions utilized by PG&E in the FSAR were determined to be conservative and therefore acceptable on the basis of a comparison of PG&E's approach to the method identified in ANS Standard 58.2.

The results of the above independent analysis indicated that all potential targets in the AFWS and CRVPS whose failure could adversely affect safety functions had not been identified in the FSAR. Those not identified included the motor-driven AFW pumps, two AFWS pressure transmitters (EOIs 8028, 8029, and

8030), and AFWS level control valves (EOI 8031). Further, cable/wire used in the AFWS and CRVPS power supplies was of a type other than that indicated in the FSAR as being qualified for elevated temperatures and is subject to fluid jet environments as are some cable splices not identified in the FSAR (EOI 8011). Other than the cable/wire and cable splices, no other CRVPS equipment is subject to high energy line crack blowdown jet effects; thus, the CRVPS was determined by the IDVP to be adequately protected.

In response to the above concerns, PG&E reevaluated the high energy line crack analysis against the FSAR commitments (Giambusso letter dated December 18, 1972). It was determined that the line established in the IDVP analysis as a source affecting the motor-driven AFW pumps and pressure transmitters (located on the steam supply line to the turbine-driven AFW pump downstream of the flow control valve) was not subject to cracks because it is not pressurized during any normal plant operating conditions, including startup and shutdown. PG&E committed to revise the FSAR to indicate the above point. The IDVP agreed with the above resolution. The staff also concurs with the resolution.

Regarding the AFWS level control valves, PG&E performed a reanalysis of the blowdown jet temperature from the postulated high energy line crack source affecting these valves using the ANS Standard 58.2 methodology in lieu of the NSC method documented in the FSAR. The results of this reanalysis showed a jet temperature below the qualification temperature for the valves. PG&E committed to revise the FSAR to incorporate this reanalysis. The IDVP concurred with the above jet temperature calculation method and the reanalysis results. The staff also concurs with the resolution.

With respect to cables/wires and splices identified as targets, PG&E responded by providing documentation that indicated that the affected cables and wires were environmentally qualified for the resulting high energy line crack blowdown jet environment and further committed to update environmental qualification documentation. The additional documentation also indicated that the cable splices were environmentally qualified for the jet environment and were located spatially to ensure that the qualification temperature was not exceeded. A subsequent field verification by the IDVP confirmed the design location of the splices in conformance with the environmental qualification criteria. The staff concurs with the above resolution.

The IDVP review of moderate energy pipe break effects on the AFWS and CRVPS consisted of examining licensing documents against the commitments identified in letters from PG&E dated September 14, 1979 and December 28, 1979. Further, a field verification was performed of the design modifications committed to for protection of safety-related equipment from the effects of moderate energy line breaks and of the adequacy of these modifications. In addition, an evaluation was performed to determine if additional moderate energy line break sources could affect CRVPS and AFWS targets.

The IDVP review confirmed that all modifications committed to for protection of AFWS equipment from the effects of moderate energy pipe breaks were implemented and adequate for protection, with the exception of those for two flow control valves (EOI 8014). Further, the licensing commitment regarding moderate energy pipe breaks was not fully complied with, since it states that all equipment required for safe shutdown was evaluated. However, CRVPS equipment, which is identified in the FSAR as necessary to maintain control room habitability during shutdown, was not evaluated and is subject to the effects of a moderate energy pipe break (EOI 8050).

In response to the above concerns, PG&E indicated that the flow control valves (suction supply valves from the alternate AFWS water source, the raw water storage reservoir) are not required to operate to ensure AFWS safety function following the postulated moderate energy line break; therefore, they are not required to be protected from the pipe break effects. PG&E will revise the licensing commitment to delete the need for protective shields for these valves. The IDVP agreed with this response. The staff also concurs with the resolution.

Regarding the failure to include the CRVPS in the original moderate energy line break analysis, PG&E provided an analysis indicating that only one CRVPS electrical train is affected by the postulated break identified by the IDVP. When combined with a single failure in the redundant electrical train, a loss of the CRVPS would occur, resulting in degradation of control room habitability. However, safe shutdown can be provided from the remote shutdown panel in the event the control room becomes uninhabitable. The IDVP concurred with this analysis. The staff believes that the above evaluation is more conservative than that required by the moderate energy pipe break criteria. Standard Review Plan (NUREG-0800) Section 3.6.1 criteria indicate that a single failure is not postulated concurrent with a moderate energy line break; therefore, one train of the CRVPS would be available following the moderate energy line break identified above. The staff considers this matter resolved.

On the basis of the staff review of the EOI files established as a result of the verification of the effects of high energy line cracks and moderate energy line breaks for the AFWS and CRVPS, and resolution of concerns identified herein, the staff concludes that the IDVP has confirmed that the criteria and licensing commitments regarding protection of safety-related equipment from the effects of high energy line cracks and moderate energy line breaks outside containment have been satisfied and that no generic concerns were identified which alter the staff's prior conclusions as stated in the SER for Diablo Canyon Unit 1.

4.2.6 Fire Protection

The IDVP reviewed the fire protection provided for a sample of systems of Diablo Canyon Unit 1. The selected sample consisted of the auxiliary feedwater system (AFWS), the control room ventilation and pressurization system (CRVPS), and the safety-related portions of the 4160-V electric distribution system. The special review was performed in accordance with the IDVP Phase II Program Management Plan.

For the assessment of the fire protection provided for the sample systems, the IDVP reviewed the following documentation:

(1) Final Safety Analysis Report, Amendment 51, Information on Fire Protection Review

(2) PG&E letter to NRC, February 6, 1978, Responses to NRC Fire Protection Review Questions

(3) PG&E letter to NRC, August 3, 1978, Revised Responses to NRC Fire Protection Review Questions

(4) PG&E letter to NRC, November 13, 1978, Revised Responses to NRC Fire Protection Review Questions, including attachment entitled "Supplementary Information for Fire Protection Review"

(5) PG&E letter to NRC, July 20, 1979, Plant Modifications Pertaining to Fire Protection

(6) Final Safety Analysis Report, Section 9.4.1, Amendment 81

The results of the IDVP review of the fire protection and the IDVP verification regarding its adequacy are presented in ITR 18 and in the IDVP Final Report, Section 4.7.

Fire zones containing equipment required for operation of the sample systems were identified. Within each of these zones, the IDVP assessed the adequacy of fire barriers in light of the PG&E commitment in the November 13, 1978, letter that a single fire will not affect the plant's safe shutdown capability or propagate beyond fire zone boundaries. In addition, the IDVP reviewed the location and extent of fire detection and fire suppression systems for consistency with PG&E commitments in referenced documents 1 and 4, above. This was also done for special fire hazard control measures, such as curbs for containment of oil spills, drainage for fire suppression water, sealed beam lighting units, and hydrogen line enclosures.

The IDVP selected a sampling of the circuit routings from the 4160-V electric system, AFWS, and CRVPS and compared them with the tabulated routings in the PG&E "Supplementary Information on Fire Protection Review" (SIFPR), dated November 13, 1978. In addition, an independent list of safe shutdown circuits was developed by the IDVP from electrical and instrumentation/control drawings. This list was compared to the circuits identified in the SIFPR. Subsequent to that review, the IDVP field-inspected the location of all power/control circuits required to perform safe shutdown functions in the AFWS and the Unit 1 portion of the CRVPS and performed an independent analysis of the power/control circuit separation. The results of the IDVP efforts and the staff evaluation of those efforts is presented in the following sections.

4.2.6.1 Auxiliary Feedwater System

In response to an earlier request, PG&E had committed to provide isolation of control room circuitry from the hot shutdown panel, subsequent to transfer of control to "local" at the hot shutdown panel. In EOI 8032 the IDVP identified that an "on-off" control switch and associated wiring essential for providing power to motors at certain AFW level control valves could be lost during a control room fire. PG&E responded that the design had been reviewed against all regulatory requirements and FSAR commitments when the switch was originally added to the control board. The design was considered to meet all requirements and commitments because the valves in question have the capability of being controlled locally. PG&E reviewed the control board power switch to achieve circuit independence. The work has been verified to be complete and the IDVP concern has been resolved.

In EIO 8038 the IDVP raised a concern that fire zone separation for the motor-driven AFW pump room was not consistent with licensing document descriptions. Specifically, a large grated ventilation opening is located in the ceiling which forms a portion of the zone boundary. PG&E responded to this concern by providing an analysis which demonstrated that a fire is unlikely to propagate through the opening because of the air flow pattern and the absence of significant combustible material. The IDVP concurred that this analysis demonstrates that a fire in this area would not adversely affect the safe shutdown functions of the AFWS.

The concern raised in EOI 8037 was that a noncombustible barrier separating the motor-driven AFW pumps from the turbine-driven AFW pump contains a fire damper that has gaps at each end of the damper blades when the damper is closed. These gaps could permit products of combustion to pass through the barrier. PG&E responded to this concern by stating that the gaps permitted thermal expansion and by providing documentation that the damper was Underwriters Laboratories (UL) approved for a 1½-hour-fire rating. The IDVP inspected the UL label on the damper and concurred that the damper meets the commitment to provide noncombustible separation between the motor-driven AFW pumps and the turbine-driven AFW pump.

In EOI 8036 the IDVP noted that two valve covers on the hydrogen line enclosures were loose and missing in the turbine-driven AFW pump room. This was contrary to licensing commitments contained in the PG&E letter of November 13, 1978, to enclose these lines to minimize potential explosion hazards in case of a hydrogen leak. PG&E replaced the valve covers. This action satisfactorily resolved the concern.

In EOI 8019 the IDVP initially noted that both motor-driven AFW pumps and control circuitry (in conduit K8317) for a flow control valve that is required for operation of the turbine-driven AFW pump are located at el 100 ft 0 in. in the auxiliary building. The concern was that a fire could damage the motor-driven AFW pumps and, at the same time, damage circuitry, which would render the turbine-driven pump inoperable. PG&E responded to this concern by demonstrating that the circuitry in conduit K8317 is not required for the safety-related operation or control functions of the flow control valve in question. The IDVP evaluated the additional information and concurred that this response adequately addresses the concern.

Discrepancies in seven power and control circuit locations that were tabulated by fire zone in PG&E's SIFPR, dated November 13, 1978, were identified in EOI 8021 as the result of the IDVP field inspection of approximately 50% of the AFW circuit routings. In addition, four circuits required for operation of AFW components identified by the IDVP were not addressed in the SIFPR. PG&E provided an analysis based on the as-built circuit routings as of November 30, 1981, which demonstrated that a fire in any one zone would not adversely affect the safe shutdown functions of the AFWS. An additional IDVP field verification of all circuit routings for AFW components required for safe shutdown and an independent fire protection analysis of the as-built circuit separation were then performed. This new analysis identified two plant areas that contained circuitry for all three AFW trains that could be affected by a single fire. In fire zone 3BB (el 100 ft 0 in. in the auxiliary building), PG&E relocated circuitry for one flow control valve out of the fire zone so that it would no longer be subject to fire damage. In the control room/cable spreading room, the IDVP determined that credit could be taken for manual operation of certain level control valves which would ensure the availability of AFW trains 1-2 and/or 1-3 in case of a control room or cable spreading room fire. Therefore, the IDVP concluded that a single fire would not adversely affect the safe shutdown functions of the AFWS.

The staff has reviewed and evaluated the IDVP fire protection verification effort and concludes that there is reasonable assurance that the significant fire protection concerns pertaining to the AFWS that were identified have been satisfactorily resolved. Identified deviations from licensing commitments were the result of PG&E misinterpretations of those commitments or the absence of up-to-date information on as-built plant conditions initially available to the IDVP and not the results of analysis or design deficiencies. The staff concludes that the concerns raised by the IDVP in the EOI files as discussed above did not reflect a significantly reduced margin of safety provided by the various aspects of the Diablo Canyon Unit 1 fire protection program; therefore, an adequate margin of fire safety does exist. The staff further concludes that the scope of the IDVP verification of fire protection for the AFWS is adequate and no additional verification is required.

4.2.6.2 Control Room Ventilation and Pressurization System

The IDVP determined in EOI 8035 that smoke detectors were not installed in the CRVPS normal ventilation intake ducts as described in Amendment 51 of the FSAR. Smoke detectors had been installed previously in the return flow path between the intake and supply ducts. This arrangement provided some smoke detection capability for the control room air. PG&E as a result of the IDVP review installed smoke detectors in accordance with the licensing commitment and this action has resolved the IDVP concern.

The concern raised by the IDVP in EOI 8020 was that power/control circuitry, required for operation of CRVPS components necessary to maintain control room habitability during safe shutdown, was only partially identified in the PG&E "Supplementary Information for Fire Protection Review." PG&E resolved this concern by providing a separation analysis for all circuits associated with required CRVPS components. The IDVP reviewed this analysis, field-verified that all Unit 1 circuits are located as described in the PG&E analysis, and concurred that the analysis demonstrates that adequate separation existed as of November 30, 1981, to maintain control room habitability during a safe shutdown.

The staff has reviewed and evaluated the IDVP fire protection verification effort and concludes that there is reasonable assurance that all significant fire protection concerns with the CRVPS have been identified and satisfactorily resolved. The staff concludes that the concerns raised in the EOIs above did not represent a significant reduction in the margin of safety provided by the various features of the Diablo Canyon Unit 1 fire protection program. Therefore, an adequate margin of fire safety exists. The staff further concludes that the scope of the IDVP verification of fire protection for the CRVPS is adequate and no additional verification is needed.

4.2.6.3 4160-V Safety-Related Electrical System

The IDVP determined in EOI 8039 that fire zone barriers for the 4160-V cable spreading rooms are not consistent with licensing document descriptions. Each of the three rooms (fire zones 12A, 12B, and 12C) has a ventilation opening leading up to the 4160-V switchgear rooms (fire zones 13A, 13B, and 13C). PG&E responded to this concern by providing an analysis that demonstrated that a fire in any of these fire zones would only affect one vital bus, and that because of the absence of combustible material, a fire would be unlikely to propagate through any of the ventilation openings. The IDVP concurred that this analysis adequately demonstrates that a single fire in or near any of the 4160-V cable spreading or switchgear rooms would not adversely affect safe shutdown capability.

The staff has reviewed and evaluated the IDVP fire protection verification effort and concludes that there is reasonable assurance that all significant fire protection concerns with the 4160-V safety-related electrical system have been identified and satisfactorily resolved. The staff concludes that the concern raised in the above EOI did not represent a significant reduction in the margin of safety provided by the Diablo Canyon Unit 1 fire protection program. Therefore, an adequate margin of fire safety exists. The staff further concludes that the scope of the IDVP verification of the fire protection for the safety-related portion of the 4160-V electrical distribution system is adequate and no additional verification is required.

4.2.7 Radiation Environmental Qualification

The IDVP reviewed sample radiation dose calculations for equipment qualification which had been performed for PG&E by Radiation Research Associates (RRA) and EDS Nuclear, Inc. (EDS) under service contracts. The IDVP sample was for two locations, one associated with the auxiliary feedwater system (AFWS), the other with the control room ventilation and pressurization system (CRVPS). The review was limited to equipment qualification dose resulting from post-LOCA recirculation outside containment. All source and dose calculations had been performed by RRA; source geometry, source parameters, and concrete shield data had been prepared by EDS for RRA. The Diablo Canyon radiation shielding review also had been prepared by EDS.

The IDVP reviewed RRA records, EDS input, and PG&E information for correct selection and incorporation of design input into the analyses, reasonableness of assumptions used in calculations, correctness of design interface information used in analyses, adequacy of design or calculational method used, and reasonableness of the output compared with the input.

The IDVP performed a calculation of the sensitivity resulting from different calculational methods to develop acceptance criteria for the comparison of results of the independent dose calculations for the location in the AFWS and for the location in the CRVPS. Using identical input data, the difference in output of the various computer programs was determined. The ORIGEN program was compared against the ACTIVITY2 and RADIOISOTOPE programs; RRA QADMOD was compared against SWEC QADMOD. Finally, an overall comparison was made to determine the composite difference of the results derived from the programs.

Verification of doses presented in the Diablo Canyon radiation shielding review was made by the IDVP by independently calculating the integrated doses at one point in the AFWS and at one point in the CRVPS. The results of this calculation were compared with RRA results, using the acceptance criteria developed in the sensitivity calculation.

Verification that the RRA and the IDVP geometric models were developed from drawings which properly reflected the as-built conditions of the plant was accomplished by a site inspection of the areas of interest. These areas are area GE of the auxiliary building, the residual heat removal system heat exchanger area, and the control room ventilation area.

The IDVP review did not identify any concerns that resulted in the issuance of an EOI file. The staff finds that the IDVP review of the radiation dose calculations was very thorough. Although many specific assumptions were not identified in sufficient detail in the report, the staff concludes that the methodology used by the IDVP in its independent calculations appears to be in general agreement with the guidelines of NUREG-0588. The staff concludes on the basis of its review of the IDVP effort that no additional verification is required.

4.2.8 Pressure and Temperature Environmental Analyses

To verify that bounding environments outside containment specified for operation of safety-related equipment in the AFWS and CRVPS had been properly determined, the IDVP reviewed samples of the pressure, temperature, humidity and submergence analyses for selected plant areas (performed by Nuclear Service Corporation (NSC) for PG&E). The turbine building and areas GE and GW of the auxiliary building were selected as the sampled areas outside containment because they could be subjected to a harsh environment caused by postulated high energy pipe (main steam and feedwater line) breaks and contain safety-related equipment for the AFWS and CRVPS.

IDVP review determined that the postulated relative humidity value of 100% throughout the original NSC subcompartment analysis was conservative and bounding. The review of submergence (internal flood) levels was based on selecting the design-basis feedwater line break in areas GE and GW as a representative of the design approach for this concern. The IDVP initially questioned the flood levels determined in the original calculations performed by NSC as being too low because of an improper consideration of available water inventory (EOIs 8005 and 8040). Subsequently, PG&E detailed the assumptions and methodology of the original analysis. Based on this additional information, the IDVP determined that the analysis results and flood levels established are conservative and in compliance with the licensing design basis and commitments. Further, because the same submergence analysis method was employed throughout the plant, no generic concern was identified in this area. The staff concurs with the above resolution.

The IDVP review determined, however, that the pressure and temperature transients calculated by NSC were too low (i.e., nonconservative); thus, the worst (bounding) environment which can be postulated from the pipe break as indicated in licensing commitments was not identified. This is primarily because the CONTEMPT computer program used by NSC in the analyses cannot effectively model adjacent compartments and their venting effect on the equilibrium temperature (EOIs 8001 and 8034). Further, credit for liquid entrainment in the NSC mass and energy release data lead to nonconservative results. Specific concerns identified by the IDVP regarding the initial temperature assumed in the subcompartments and the limiting break configurations were resolved by PG&E on the basis of a verification and clarification of the initial licensing commitments (EOIs 8002 and 8004). The staff concurs with the above resolution.

The basis for the above IDVP findings regarding the computer calculational method was an independent analysis performed by the IDVP using the Stone & Webster THREED computer code. Input to the IDVP analysis was the same as that for the NSC work so that the sensitivity of the input assumptions could be examined, the CONTEMPT and THREED outputs could be compared, and the differences in pressure/temperature transient calculations attributable solely to the computer program itself could be determined. Because of the problems identified with the use of CONTEMPT in determining environmental conditions outside containment and the fact that this computer program had been used extensively by NSC for this purpose, the above concern was determined to be generic in nature and thus required additional verification as discussed in Section 4.3.3.

In response to this concern, PG&E reanalyzed all subcompartment environmental conditions resulting from postulated high energy line breaks outside containment. The reanalyses also incorporated IDVP concerns regarding assumptions on door positions, mass and energy release calculations, proper documentation of the turbine building vent area, and use of appropriate enthalpy values (EOIs 8003, 8006, and 8033). The Bechtel FLUD computer program was used in this work. Results obtained from the reanalysis of areas GE and GW were determined to be consistent with the IDVP analyses using THREED as discussed in Section 4.3.3. The staff concurs with this resolution as discussed further below. PG&E is using the newly determined temperature/pressure conditions in compartments outside containment to verify that compartment walls are adequate and previous safety-related equipment environmental qualification is not affected. Modifications to areas GE and GW of the auxiliary building have been found necessary and are being implemented. These include strengthening compartment doors and blockouts, installing flow limiters at the main steamline containment penetrations, and modifying vent openings for pressure relief in order to maintain safety-related equipment qualification temperature within the area environmental envelope. Further discussion of the additional verification and reanalysis of consequences resulting from pipe ruptures outside containment is contained in Section 4.3.3.

Additionally, because of the nature of the above concern and the staff's continuing generic effort in the area of equipment qualification, the staff undertook its own evaluation of the pressure/temperature transients resulting from pipe ruptures (main steamline break) utilizing the COBREE computer program developed by Pacific Northwest Laboratories for the staff for this purpose. The staff has analyzed the GE and GW compartments using the same input data provided to the IDVP and has obtained results consistent with the PG&E FLUD reanalysis.

On the basis of the staff review of the EOI files established as a result of the verification of pressure, temperature, humidity, and submergence environments used for safety-related equipment specification outside containment for the AFWS and CRVPS, resolution of concerns identified herein, and the staff's independent analysis, the staff concludes that the IDVP has confirmed that the criteria and licensing commitments regarding determination of environmental effects in the turbine building and in areas GE and GW of the auxiliary building resulting from postulated rupture of piping outside containment used in safety-related equipment specification have been satisfied. Further, the staff concludes that the prior conclusions stated in the SER for Diablo Canyon Unit 1 are not altered. Discussion of the additional verification of the generic concern identified with respect to environmental consequences of postulated pipe ruptures outside containment is contained in Section 4.3.3.

4.3 Additional Verification

4.3.1 Redundancy of Equipment and Power Supplies in Shared Safety-Related Systems

As a result of the concerns regarding failure of the shared control room ventilation and pressurization system (CRVPS) to meet the licensing commitment for redundancy and the single failure criterion, the IDVP determined that all other shared safety-related systems should be reviewed for this potential design deficiency. This review verified that the only other shared safety-related system was the diesel fuel oil transfer system (DFOTS).

PG&E performed an analysis of the DFOTS to determine if concerns regarding power supply redundancy similar to those identified in the CRVPS design applied. The analysis assumed single failures with and without the availability of Unit 2. No single failure affecting the DFOTS safety function was identified.

The IDVP reviewed the above PG&E single failure analysis and performed an independent failure analysis utilizing the PG&E design documentation. The IDVP verified that the PG&E analysis properly assumed DFOTS operation with only Unit 1 vital power available and both Units 1 and 2 vital power supplies available. Individual component failures were also assumed.

The IDVP verified that a single failure will result in loss of only one train of the DFOTS. Therefore, the DFOTS has adequate power and component redundancy to meet the single failure criterion and perform its safety function.

On the basis of the staff review of the additional verification of the redundancy of equipment and power supplies in shared safety-related systems at the Diablo Canyon Nuclear Power Plant, the staff concludes that the IDVP has confirmed that the criteria and licensing commitment regarding redundancy to ensure safety functions in shared systems when assuming a single failure have been satisfied. Therefore, prior staff conclusions stated in the SER for Diablo Canyon Unit 1 are not altered.

4.3.2 Selection of System Design Pressure and Temperature and Differential Pressure Across Power-Operated Valves

As a result of concerns regarding compliance with applicable design codes for the selection of the auxiliary feedwater system (AFWS) design pressure, isolation of low-pressure portions of the system from high-pressure portions, and the specification of low differential pressure for the motor-operated steam supply valves to the AFW turbine-driven pump, the IDVP determined that additional sampling in these areas was required. PG&E undertook a review of the above concerns for all safety-related systems within their design scope. Although system design temperature was not identified as a concern in the initial sample, component design is a function of both pressure and temperature. Thus, changes in the pressure specification may affect the allowable temperature, and, therefore, design temperature was also considered.

The PG&E review included confirming design pressure and temperature for all 10 safety-related and safety-related portions of nonsafety-related systems within their design responsibility. Calculations were performed to document code compliance for each system specification. System component design specifications were compared to the calculated pressures and temperatures to determine if they are compatible for the design conditions. Those that did meet the new conditions were resolved by analysis or design change.

The PG&E review of differential pressure across power-operated valves consisted of developing a list of valves in the above 10 systems and establishing the specified maximum differential pressure from the valve data sheets or vendor information. This value was compared to the design maximum differential pressure at which each valve is required to operate in order to verify the acceptability of the valve. A conservative value of 80% of actual voltage was used in the reanalysis for verifying valve operability.

The IDVP additional review in this area consisted of selecting a sample from two safety-related systems within the PG&E design scope and independently determining system design pressure and temperature, and differential pressure across power-operated valves. The component cooling water system (CCWS) and safety-related portions of the main steam system (MSS) were selected for this review. PG&E-specified design values were compared to the IDVP calculated values, and compliance with code requirements for design conditions and low-/high-pressure interconnections were verified.

The above IDVP review determined that the PG&E reanalysis method for the CCWS and MSS was satisfactory and met the intent of the applicable code for selection of the most severe system pressure and temperature. Further, the IDVP determined that PG&E properly established differential pressure across power-operated valves. The IDVP concurred with the results of the PG&E reanalysis. In addition, the IDVP reviewed the CCWS and MSS arrangement drawings to determine code compliance for protection of low-pressure portions of the system. The IDVP verified code compliance in this area.

The results of the reanalysis indicated that system design pressure and temperature conditions were higher than originally specified for the MSS and CCWS; thus, concerns similar to those in the initial AFWS sample review were found to exist. PG&E compared component design ratings to the new conditions and determined that the MSS satisfies the code criteria with the exception of system steam traps. The steam traps will be modified. No low-pressure interconnections exist in the safety-related portions of the MSS. All MSS safety-related valve actuators are capable of operation against the newly calculated differential pressure with the exception of the AFW turbine-driven pump steam supply valve identified in the initial sample. PG&E will rereview this valve against the recalculated MSS design conditions. The CCWS components were compared to the new design conditions, and it was determined that the system satisfies the code criteria with the exception of the reactor coolant pump upper and lower bearing oil coolers, the CCWS pump lube oil coolers, the excess letdown heat exchanger, certain relief valves, and the reactor coolant pump thermal barriers. PG&E will reanalyze and modify the above components as necessary. High-/low-pressure interconnections in the CCWS are acceptably protected and isolated. All CCWS valve actuators with four exceptions are capable of operation against the calculated maximum differential pressure. The above four valves are under review by PG&E. Because the IDVP's concern was selection of system design pressure and temperature, and differential pressure across power-operated valves and its use in equipment specification rather than the engineering process for determining equipment acceptability, the IDVP will not verify specific changes made by PG&E as a result of the reanalyses in this area. The IDVP has verified acceptablity of the PG&E approach to resolving these concerns.

On the basis of the staff review of the additional verification of the selection of system design pressure and temperature and differential pressure across power-operated valves, the staff concludes that the IDVP has confirmed that the code requirements, licensing commitments, and criteria for ensuring safety-related system functions in this review area have been satisfied; therefore, prior staff conclusions as stated in the SER for Diablo Canyon Unit 1 are not altered. The staff will confirm that any modifications required in safety-related systems to satisfy pressure/temperature rating and power-operated valve operability under proper differential pressure conditions are implemented.

4.3.3 Environmental Consequences of Postulated Pipe Ruptures Outside Containment

As a result of the concerns regarding the adequacy of the determination of environmental consequences resulting from postulated pipe ruptures outside containment, PG&E undertook a reanalysis of all pressure and temperature transients for pipe ruptures outside containment. The IDVP review consisted of a detailed examination of the PG&E reanalysis for areas GE and GW of the auxiliary building and the turbine building and a review of the environmental conditions established in the reanalyses for other areas outside containment.

The IDVP review of the PG&E calculational method consisted of a sensitivity study that compared the Stone & Webster THREED computer program results to the Bechtel FLUD computer program reanalysis using identical inputs. The sensitivity study was undertaken to identify differences in the calculational results attributable solely to the computer program itself. The comparison analysis was for a postulated main steam pipe rupture in area GW of the auxiliary building and its effects on area GE of the auxiliary building.

The IDVP also performed independent calculations using THREED for pressure/temperature transients from a postulated main steamline rupture in areas GE and GW of the auxiliary building and the turbine building. The results of these calculations were compared to the Bechtel FLUD computer calculations. The IDVP determined that PG&E has used a computer program that properly modelled the multiple nodes representing areas GE and GW and the turbine building, properly determined input data, utilized appropriate mass and energy release data and break sizes, and conservatively assumed door positions to maximize the pressure and temperature transients in the above areas. Certain doors were assumed to remain closed based on their design capability. Others were assumed to open once their design pressure was exceeded. These assumptions will be verified in PG&E's continuing pressure/temperature transient reanalysis program.

The results of the above FLUD/THREED comparison indicated slight differences in the calculated peak pressures and temperatures. PG&E results were generally slightly more conservative than those of the IDVP because of minor variations in Westinghouse-supplied mass and energy input data and area dimensional inputs. The IDVP confirmed that the PG&E reanalysis established appropriate pressure and temperature transients in area GE of the auxiliary building and the turbine building.

The IDVP review also included a review of the PG&E reanalyses of pressure and temperature transients in the remaining areas of the auxiliary building. This review was performed to verify that the calculational method found acceptable above was being used by PG&E for all reanalyses. The IDVP verified that the PG&E procedure for identifying high energy lines, break locations, compartments containing safety-related equipment, and the models utilized were acceptable. The IDVP determined that break types were in accordance with the Giambusso letter dated December 18, 1972 (staff criteria) as committed to in the FSAR. It was also determined that the hand calculations and computer program calculations (RELAP 4 MOD 5) provided appropriate mass and energy release data for the postulated pipe breaks. Input assumptions, such as door positions, were also consistent with those in the previous calculations.

The IDVP review of the resulting pressure and temperature transient conditions determined that the reanalyses methodology for the remaining auxiliary building areas was consistent with that used in areas GE and GW and in the turbine building. PG&E indicated that results obtained are conservative for the break compartment. The PG&E continuing reanalysis of pressure and temperature transients will include effects of ventilation system operation in order to enhance the results obtained for compartments adjacent to the break. PG&E has committed to make any modifications necessary as a result of this reanalysis, and provide revised documentation of this work as a followup to EOI 8001 and associated EOIs. The IDVP concluded that the reanalyses satisfactorily resolved the IDVP concerns. Because of this conclusion, the IDVP determined that a further verification of the PG&E continuing effort in the selection of pressure and temperature conditions and associated environmental qualification of safety-related equipment was not necessary.

On the basis of the staff review of the additional verification of the environmental consequences of postulated pipe ruptures outside containment, the staff concludes that the IDVP has confirmed that the licensing criteria and commitments for ensuring qualification of safety-related equipment to proper pressure and temperature transient conditions have been satisfied. Therefore, prior staff conclusions as stated in the SER for Diablo Canyon Unit 1 are not altered. The staff will evaluate PG&E submittals updating the equipment environmental qualification documentation resulting from the reanalyses.

4.3.4 Circuit Separation and Single Failure

The following generic concern, identified by the IDVP in the initial sample review, required additional verification, as recommended by the IDVP, to ensure that similar concerns do not exist for other safety-related systems.

The IDVP initial sample review of the auxiliary feedwater system (AFWS) and the control room ventilation and pressurization system (CRVPS) identified electrical circuits and components that did not meet separation or single failure requirements in accordance with commitments and design criteria specified in the licensing documents for the Diablo Canyon plant. In EOI 8017 the IDVP identified redundant control power sources that come together in a single device separated only by the mechanical and electrical features of the device. In EOI 8057 the IDVP identified redundant cabling (routed to instruments or devices located in panels) that came together in a common cable bundle with the mechanical and electrical properties of the insulation of each cable providing separation.

PG&E, as a result of the above-identified items of concern, performed a review and made modifications or performed analysis as needed to ensure that all safety-related circuits and components meet design separation and single failure requirements. The IDVP verified the results of the PG&E review, analysis, and modifications on a sample basis for the following systems: component cooling water, auxiliary saltwater, auxiliary building ventilation, and 125-V dc emergency power. The IDVP concluded, on the basis of this sampling, that the design, subsequent to the PG&E review, modification, and analyses, meets the separation and single failure requirements specified in the licensing documents for the Diablo Canyon plant. Based on the IDVP review, the staff concludes that this concern has been acceptably resolved and that additional verification is not required.

4.3.5 Jet Impingement Effects of Postulated Pipe Ruptures Inside Containment

The IDVP reported in its Phase I Quality Assurance Audit and Review Program that specific PG&E documentation concerning the analysis of jet impingement effects on components inside containment as specified in FSAR Section 3.6 could not be located. On the basis of this review, the IDVP issued EOI 7002, classified as an A/B error.

4.3.5.1 Diablo Canyon Project Effort

In response to EOI 7002, the Diablo Canyon Project (DCP) established a program to perform a formal analysis of jet impingement inside containment. The purpose of the DCP jet impingement analysis is to ensure that, following postulated high energy pipe breaks inside containment, the plant can be placed in a safe shutdown condition, the consequences of the accident can be mitigated, and site boundary radiation exposure limits are not exceeded.

The jet impingement analysis consisted of the identification of all high energy break locations inside containment; definition of the zone of influence in which postulated jets can cause damage; identification of safety-related structures, systems, and components within the zone of influence; and performance of safety evaluations to ensure that safety-related structures, systems, and components required to function following the postulated break are available.

The analysis for components is essentially complete, and the need for modifications has been identified in one area. The modifications will be either the addition of pipe restraints in the area or the relocation of a few components.

Modifications, if any, with respect to structures and piping systems have not yet been identified.

4.3.5.2 IDVP Effort

The IDVP Phase II Program Management Plan requires that a verification sample be considered in cases where pertinent documentation is not available. The IDVP selected a sample of the DCP documentation of the jet impingement reanalysis for verification as defined in ITR 34.

The sample review by the IDVP was performed by the Stone & Webster Engineering Corporation (SWEC). It comprised a review of the DCP analysis procedure MEP-1 "Engineering Procedure for the Analysis of Jet Impingement Effects Inside Containment," and the DCP document control manual DCM M-65, "Jet Impingement Analysis Criteria for Inside Containment"; a verification of the DCP implementation of the procedures, including a field walkdown; and a review of the DCP evaluation of jet-target interactions.

The analysis procedure was reviewed to ensure that it

(1) provided the basis for a documented jet impingement program
(2) met the licensing commitments in FSAR Section 3.6
(3) described a comprehensive jet impingement review program

A field walkdown verified the implementation of the DCP procedure.

In addition, utilizing the DCP jet impingement review results for a sample of high energy lines, the IDVP verified the jet-target interactions of each postulated line break and is reviewing the safety effects of each on safety-related equipment.

As a result of the IDVP verification, four items of possible concern were identified and reported in EOI 8065. These items pertain to jet impingement effects on safety-related piping, supports, and conduit. The DCP will perform a safety evaluation to resolve these items.

4.3.5.3 Safety Evaluation

The review of jet impingement effects by DCP and SWEC has as yet not been completed. The approach considered by the IDVP appears to be technically adequate. However, sufficient information has not been provided in the IDVP Final Report to permit a final assessment by the staff concerning the adequacy of the DCP corrective action or the quality of the IDVP review. The IDVP will report its findings in a future ITR. This is, therefore, considered to be an open issue whose resolution will be reported in a supplement to the SER.

The staff finds that the DCP has not as yet demonstrated, nor has the IDVP verified, that possible jet impingement loads were considered in the design and qualification of safety-related piping and equipment inside containment. This is, therefore, considered an open safety issue whose resolution will be reported in a supplement to the SER. The staff, therefore, considers the DCP and IDVP efforts reported so far acceptable only for meeting the requirements for fuel load authorization.

4.3.6 Rupture Restraints

4.3.6.1 IDVP Verification of the DCP Corrective Action Program

The IDVP verification of the DCP Corrective Action Program for rupture restraints consists in examining the qualification of rupture restraint designs for pipe rupture loadings. The IDVP review includes field inspection to ensure conformance of design drawings to as-built conditions for selected DCP calculations. For restraints outside containment this activity is outlined in ITR 35 and is being performed by Robert L. Cloud and Associates (RLCA). No information is as yet available on the IDVP verification of the DCP review of rupture restraints inside containment.

Rupture restraints are provided to restrain high energy pipes of 1-in. diameter or more. The postulated pipe break locations are determined on the basis of the stress effects resulting from pressure, deadweight, thermal expansion, fluid transients, and design earthquake during normal upset and test conditions. High energy pipes are defined in the Diablo Canyon FSAR as pipes having a service temperature and design pressure exceeding 200°F and 275 psig.

The DCP has conducted its evaluation of rupture restraint criteria implementation and qualification analyses through an Internal Technical Program (ITP). The purpose of the DCP evaluation was to demonstrate the adequacy of the as-built rupture restraints designed by Nuclear Service Corporation (NSC), currently known as Quadrex.

The DCP methodology was based on the selection of a representative sample according to restraint configurations and piping systems. The sample was selected by grouping all the restraints specified in NSC's Structural Evaluation Report by configuration (30 groups) and then selecting the restraints that appear to be the critical cases. Approximately 25% to 40% of the restraints in each group were selected for evaluation. The selection was based on member size, applied pipe rupture load, design margins, and engineering judgment. For each restraint substructure selected, the corresponding U-bolt/rod assemblies were identified and evaluated. In addition, the DCP methodology required evaluation of the remaining restraints in a group if a modification was required to a restraint within a specific group.

The following items were included in the DCP review:

(1) comparison of as-built drawings with design drawings
(2) generic studies related to the NSC reports
(3) design load verification
(4) verification of the adequacy of design and construction of

- (a) restraint substructure (frames)
- (b) building attachments (base plates and anchor bolts)
- (c) U-bolts/rod beams and gaps
- (d) restraint weldments
- (e) building elements (e.g., walls, columns)

(5) testing program for U-bolt anchorages and couplings

The DCP review calculations were tabulated on a calculation index log which grouped calculations by category: generic, U-bolt/rod beam, substructure, and specific weld evaluation.

The IDVP selected a sample of the DCP qualification analyses to ensure conformance to criteria and accuracy of calculations. The sample was chosen to assess the essential steps of the qualification process.

Before actual sample selection, the IDVP reviewed the Diablo Canyon FSAR (for pipe break/restraint locations and gap characteristics) as well as the DCP rupture restraint calculation index log. This DCP log listed approximately 210 calculations in the categories named above. The IDVP selected for review 12 rupture restraints involving 25 individual calculations. Specific restraints were selected for review based on the following considerations:

(1) a variety of systems and plant locations

(2) critical restraints based on location (e.g., close to containment or control room)

(3) gap characteristics

(4) combination of calculations addressing U-bolts, substructure, and weld evaluation

The IDVP is performing design reviews for the DCP analyses selected. It is also reviewing generic calculations listed in the DCP calculation index log based on their applicability to the specific IDVP design review samples. Alternate calculations are being performed by the IDVP where necessary to assess the effects of various DCP assumptions and calculations.

The IDVP intends to formulate final conclusions as to the qualification of rupture restraints and their conformance to licensing criteria when the IDVP review of calculations is complete. This activity will be reported in a forthcoming ITR.

4.3.6.2 Safety Evaluation

The review of rupture restraints outside and inside containment conducted by the DCP and verified by the IDVP has as yet not been completed, and no submittal from the DCP has been received.

The approach considered by the IDVP appears to be technically adequate. However, insufficient information has been provided in the IDVP Final Report to permit a definite assessment by the staff concerning the adequacy of the DCP corrective action or the quality of the IDVP review. In addition, no information has as yet been submitted on the IDVP verification of the DCP review effort on restraints inside containment.

The staff finds that the DCP has not as yet satisfactorily reviewed the restraints nor has the IDVP verified that the rupture restraints outside and inside containment have been properly designed and installed to provide protection against postulated ruptures in high pressure piping. This is, therefore, considered an open safety issue whose resolution will be reported in a supplement to the SER. The staff considers the DCP and IDVP efforts reported so far acceptable only for meeting the requirements for fuel load authorization.

5 SUMMARY AND CONCLUSIONS

5.1 Summary

Section 1 of this report describes in detail the IDVP methodology for the verification effort and the process by which concerns or questions raised during the review and evaluation were identified and tracked through the Error or Open Item (EOI) file system until they were resolved. As of June 30, 1983, a total of 321 EOIs had been opened. Appendix D to the IDVP Final Report provides a complete listing of the EOI files including file revisions throughout their process of resolution. The list below is a breakdown of the 321 EOIs according to the IDVP organization that opened the files:

Organization and Activity	EOIs Open
RLCA (Phase I and II)	212 (66%)
RFR (Phase I and II)	6 (2%)
SWEC (Phase II)	65 (20%)
SWEC (CQA)	29 (9%)
TES (Phase I and II)	9 (3%)

As explained in Section 1, an EOI file was opened when a question or concern was raised on the part of the IDVP regarding the design or another aspect of a particular system or program under review. The validity of the concern or question was subsequently determined and the EOI file was appropriately classified. Listed below is a summary breakdown of the 321 EOI files according to the Finding and Observations classification explained in Section 1.

EOI Classification	EOIs
Findings	25 (8%)
EOIs Combined with Finding	47 (15%)
Observations	137 (42%)
None of above	108 (34%)
Unresolved	4 (1%)

EOI files that were combined with a finding were not a finding in themselves, but were of a similar subject and could best be resolved in conjunction with a finding. "None of above" refers to those EOI files that were determined to be not appropriate or invalid based on further examination of the initial concern. They account for one third of all the EOI files that were opened. Four files are unresolved at this time. This means their classification has not been determined. Their resolution will be addressed in a future supplement. The majority of EOI files (42%) fall in the category of observation. The concerns raised in those files apply to incorrect engineering or installation of safety-related equipment. However, any corrective action taken by PG&E on such files was verified by the IDVP.

Less than 10% of the 321 EOI files were determined to be of sufficient significance to be classified as a finding, i.e., license application criteria or operating limits were exceeded. A list of the 25 findings is presented in Table C.5.1. However, even those EOIs classified as findings vary greatly in their individual significance, some addressing only a discrete item and others encompassing a number of concerns related to a given structure. As noted in Table C.5.1 of the 25 findings, 7 have been totally completed as of June 30, 1983.

As stated by the IDVP in its Final Report and in the last July IDVP semi-monthly report (issued after the June 30, 1983, cutoff date for this SER), many activities are still in progress, in particular those that resulted from the Corrective Action Program for structures, systems, and components. The corrective actions by PG&E are well under way at this time. The IDVP will provide its assessment of the verification effort to the staff in future ITRs and/or revisions to the Final Report.

From its review and evaluation of the DCP and IDVP efforts and based on the information submitted to the staff as of June 30, 1983, the staff has identified a number of concerns that require future action by the IDVP and/or PG&E. These specific concerns are described in Sections 3 and 4 of this report. They involve such considerations as the appropriateness of modeling and assumptions; applicable requirements, criteria, and codes; and proper loads to be applied. These concerns must be resolved in accordance with a schedule consistent with the provisions of the Commission Order.

5.2 Conclusions

The Commission Order CLI-81-30 and the NRC letter of November 19, 1981, set forth specific requirements for the Independent Design Verification Program effort that must be completed before any consideration for reinstatement of the suspended low power license and issuance of a full power license. It is evident at this time that the scope and depth of the verification effort by both the IDVP and PG&E far exceed that which had been anticipated at the time that the above actions were taken. Nevertheless, the objective of the verification effort has not changed during the course of the effort, i.e., providing assurance that any weakness in the execution of quality controls in the design of Diablo Canyon Unit 1 have been identified and accounted for by corrective action.

Although final verification of certain matters and some modifications in the plant remain to be completed, it is possible at this time to arrive at certain conclusions with respect to some of the requirements for the verification program. Overall, the staff concludes (1) that the verification efforts undertaken have identified all significant design deficiencies that may have existed and (2) that (subject to verification, as described previously) appropriate corrective actions have been and will be taken to ensure that the design of the facility conforms to the licensing criteria. Accordingly, the staff recommends that the authority to load fuel and conduct low-power testing (up to 5% of rated power), suspended by the Commission's Order, be reinstated, subject to staff verification of satisfactory completion of all efforts presently under way which are required for the license activities authorized.

Independence

The staff concludes that the verification program under the management of Teledyne Engineering Services was conducted as an effort independent of direction and influence by PG&E and PG&E contractors, principally the Bechtel organization. This conclusion is a judgment by the staff which is based on the staff's verification of financial independence and other relationships between the IDVP organizations (and its employees assigned to the IDVP) from PG&E and Bechtel. This judgment also is based on the staff determination that the IDVP guidelines related to conflict of interest and to interactions between the IDVP and PG&E were adequate and have been implemented throughout the program. The very nature of the verification program required frequent interaction and information flow between the IDVP and PG&E. While in this process differing viewpoints on specific technical issues were expressed, the staff finds that the IDVP personnel performed their assignments in an objective and professional manner and were not unduly influenced by differing PG&E viewpoints.

Reporting

The Commission Order and the NRC letter required that the IDVP periodically provide status information to the staff and issue final reports at the completion of the Phase I and Phase II activities. The staff was kept informed of the status of the IDVP in an appropriate and satisfactory manner through its semi-monthly reports.

In addition, the IDVP Interim Technical Reports (ITRs) provided intermediate conclusions while efforts were still in progress and served a very useful purpose. The IDVP Final Report is responsive to the specific Commission requirements and will be updated as additional efforts are completed.

In addition to the IDVP reporting, the staff also received status information from PG&E on a semi-monthly basis. In accordance with the Commission Order, PG&E submitted the Phase I and Phase II Final Reports. While the staff concludes that those reports properly address the verification effort as of the date of their issuance, it expects that PG&E will supplement the reports upon completion of the activities.

Quality Assurance

The underlying reason for the Independent Design Verification Program was the concern that the breakdown in quality controls between PG&E and the PG&E seismic design service contractors (which directly contributed to the "diagram error") was of a generic nature, i.e., potentially could also exist with respect to other service contractors and within the PG&E organization itself. The staff concludes that the IDVP performed a thorough and professional audit and review of the quality assurance programs of seismic and nonseismic service-related design contractors and of the implementation of these programs at the time of the respective design activities. The IDVP determined that some design work by PG&E and by some of their service-related contractors was conducted at various times without a formal QA program; however, awareness and a positive quality assurance attitude existed in many cases. The staff concurs with the findings of the IDVP; however, the staff concludes that many of the design uncertainties and deficiencies that were identified during the IDVP effort can be directly attributed to poor interfacing between design organizations and poor documentation of the design process.

Regarding quality assurance matters as related to design activities during the last two years (i.e., during the time the IDVP was being conducted), the staff concludes that these activities have been and are being performed in accordance with a quality assurance program that was approved by the staff in 1982.

During the process of the IDVP, the scope of quality assurance audits was expanded to include auditing on a sample basis, quality assurance programs and their implementation as applied to construction activities. The IDVP determined that while there was one instance of inadequate documentation, work in constructing Diablo Canyon Unit 1 was performed under appropriate quality assurance controls and was satisfactory. The staff concludes that the IDVP audit scope and depth are acceptable and that the IDVP conclusions are appropriate. The staff concludes that the construction quality assurance audit provides additional assurances that Diablo Canyon Unit 1 construction is acceptable.

Modifications

The seismic design verification of Diablo Canyon Unit 1 resulted in numerous modifications to the containment annulus structure, the fuel handling building superstructure, and the turbine building superstructure. A second category of modifications consisted of the strengthening and relocation of numerous pipe supports, the addition of bracing to cable trays, and local bracing of equipment cabinets.

The IDVP verification effort consisted initially of evaluation by sample of as-built conditions and design calculations including performance of independent calculations where deemed necessary. Subsequent to the formation of the DCP to undertake wide-scale review and corrective action, the IDVP effort turned to review of the DCP calculations and verification of field modifications.

Based on its review and technical audits and independent calculations, the staff finds the organization and execution of these tasks to be consistent with the approved program plan in compliance with Commission standards for quality assurance programs and the high standards of engineering practice.

The DCP review effort consisted of verifying the as-built configuration of the plant against design drawings, wide-scale reanalysis of the plant, and evaluation of the Hosgri, DE, and DDE reports. The results of the DCP calculations and parametric studies were reviewed by the IDVP.

Sample Approach

The Commission Order and the NRC letter require that the IDVP develop criteria for independent calculations and perform these calculations on a sample basis. The IDVP criteria for sample calculations and selection of sample evaluation areas was contained in the IDVP plans for Phase II, as approved by the staff and Commission. For Phase I the IDVP had selected an initial sample of structures, systems, and components for the seismic design verification. The

Corrective Action Program, initiated in early 1982 by PG&E, was the result, in part, of the IDVP findings regarding the initial sample. This PG&E program greatly expanded the scope of the seismic design verification effort because it included all safety-related structures, systems, and components. Because of this expansion, the IDVP did not bring to resolution the specific concerns raised on the sample basis; instead, the IDVP applied the sample verification approach to the PG&E corrective action effort. The staff concludes that the initial sample approach by the IDVP, the expansiveness of the effort by PG&E in its Corrective Action Program, and the application of the sample approach by the IDVP to that program are responsive to and meet the Commission's requirement for a sample approach.

With respect to the nonseismic design verification of Phase II, the IDVP selected an initial sample and based on the results of this review performed a generic review of certain aspects. The staff concludes that the limited findings under this effort did not warrant an expansion of the program as in Phase I and that the initial sample and the subsequent generic review met the requirements of the NRC letter.

<u>Basic Cause</u>

The Commission Order and the NRC letter require that PG&E provide the NRC with a technical report that assesses the basic cause of design errors identified by this program. PG&E responds to this requirement in Section 1.8 of the Phase I Final Report, and the IDVP responds to the requirement in Section 6.3 of its Final Report. PG&E concludes that there is no single basic cause for the design errors that were identified by PG&E and the IDVP, but that there were a number of possible contributing causes. These causes can be placed in three categories:

(1) causes relating to the evolution of technology, criteria, and requirements coupled with control of the iterative engineering process

(2) causes involving interfaces and communication

(3) causes of an isolated nature that generally do not fit in either of the above two categories

PG&E concludes that the first of these causes appears to be the most pervasive one.

The IDVP identified numerous underlying factors that contributed to two basic causes for the seismic design errors. These underlying factors are

(1) Safety-related systems for Diablo Canyon Unit 1 were seismically designed first in the late 1960s for the design earthquake (DE) and again in the late 1970s for the Hosgri event. There are two sets of design criteria with a substantial interval of time between the two designs.

(2) In addition to two complete seismic designs, the plant had substantial additional design work performed as a result of recent NRC IE Bulletins and TMI requirements.

(3) This multiple design work has occupied 15 years of calendar time.

(4) Seismic design technology had advanced from a rudimentary effort in 1967 to a reasonably mature, systematic, and sophisticated process today. In the natural course of this evolution, methodology and criteria have changed significantly.

(5) Nuclear plant design naturally requires the transfer of large amounts of design information from one design group to another. In the case of Diablo Canyon Unit 1, these design interfaces existed in especially large numbers both within PG&E and between PG&E and independent firms.

(6) Design document control practices in use at the time of the original design were not consistent with the eventual duration and complexity of the design process.

The IDVP concludes that these factors contributed to the following two basic causes common to most of the IDVP findings.

(1) defective transfer of information across design interfaces, i.e., control of design interfaces

(2) inadequacies in documentation and interpretation of design

The staff concurs with PG&E and the IDVP that the basic causes identified were the major contributing factors to the design errors found during the course of the verification effort.

In addition, the staff concludes that the basic causes identified must be more fundamentally attributed to the failure of PG&E management to recognize, at the time of the Hosgri reevaluation, the significance of the revised seismic design requirements and the attendant need to implement a rigorous and well-controlled redesign effort. This basic cause relates to a PG&E activity that was completed in the late 1970s. Through the independent design verification program and the PG&E corrective action program this past activity has now been reviewed and reanalyzed. Furthermore, PG&E management now demonstrates an effective awareness of the need to ensure rigorous implementation of appropriate controls. For these reasons, the staff concludes that the consequences of this basic cause have been identified and corrected through the IDVP and PG&E efforts. The staff also concludes that there is reasonable assurance that no further significant deficiencies in the design of Diablo Canyon Unit 1 remain undetected.

Table C.5.1 List of IDVP findings

EOI file	Subject	Error class	Completion status
932	Containment spray system piping support	A	Yes
938	Valve orientation in chemical volume and control system	A	No
949	Main annunciator cabinet - stiffness assumption	A/B	Yes
963	Containment spray system piping support	B	Yes
983	Electrical raceway supports - use of proper spectra	A	No
1003	HVAC duct supports - use of Hosgri loadings	A/B	No
1014	Containment seismic reevaluation (annulus steel structure, interior concrete, exterior concrete)	A/B	No
1022	Intake structure reevaluation	A/B	No
1026	Turbine building reevaluation	A/B	No
1069	Support for valves in AFWS	A	No
1092	Fuel handling building reevaluation	A	No
1097	Auxiliary building reevaluation	A/B	No
1098	Piping reevaluation (large- and small-bore piping and supports)	A/B	No
1106	Nozzle load and valve acceleration	A/B	No
1107	Piping system sample 110 (support, vent valve, and weld connection)	A	No
1124	Auxiliary building control room floor slab - discrepancy between model and as built	B	No
7002	Documentation of analyses of jet impingement inside containment	A/B	No
8001	Calculation of environmental conditions outside containment	A/B	No
8009	Design pressure of AFWS	A	Yes
8010	Overpressure protection to AFWS pump bearing coolers	A	Yes
8012	Electrical power supply system redundancy for CRVPS	A	No

Table C.5.1 (Continued)

EOI file	Subject	Error class	Completion status
8017	Separation and single failure in CRVPS safety-related redundant power sources	A	Yes
8057	Separation of instrument and control circuits for AFWS and CRVPS	A	Yes
8062	Pressure differential across control valve in steam supply to AFW pump turbine	A	Yes
9026	Documentation of liquid penetrant inspection	NA	Yes

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CODES AND STANDARDS

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American Institute of Steel Construction (AISC), "Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings," Edition 7 and Edition 8.

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American National Standards Institute (ANSI) B31.1-1973 Summer Addenda, "Power Piping."

---, N45.2.23, "Qualifications of Quality Assurance Program Audit Personnel for Nuclear Power Plants," 1978.

American Nuclear Society (ANS) Standard 58.2.

American Society of Mechanical Engineers, "Boiler and Pressure Vessel Code" (ASME Code), Section VIII, "Rules for Construction of Pressure Vessels."

---, Section III, Subsection NF, "Components Support."

Institute of Electrical and Electronics Engineers (IEEE) 344-1975, "Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations."

Structural Engineers Association of California (SEAOC) Code, 1974.

7 CHRONOLOGY PERTAINING TO DIABLO CANYON UNIT 1 VERIFICATION EFFORTS

September 22, 1981	Issuance of Facility Operating License No. DPR-76, authorizing fuel load and 5% power.
September 29, 1981	Board Notification 81-27 regarding potential deficiency in the seismic analysis of certain piping systems.
September 30, 1981	Board Notification 81-28 regarding potential deficiency in the seismic analysis of certain piping systems.
October 9, 1981	Meeting with licensee to discuss adequacy of seismic design of certain piping systems.
October 12, 1981	Letter from licensee to NRC Region V transmitting Licensee Event Report 81-002.
October 14-16, 1981	Meeting with licensee to conduct audit review of seismic design of selected systems.
October 16, 1981	Board Notification 81-29 forwarding transcript of October 9 meeting.
October 23, 1981	Board Notification 81-33 forwarding meeting summary dated October 19, 1981.
October 23, 1981	Letter from licensee providing description of status and schedule of work being performed on seismic analysis review.
October 27, 1981	Letter from licensee concerning progress of work on seismic analysis.
October 27, 1981	Letter from licensee to NRC Region V transmitting Supplement 1 to Licensee Event Report 81-002.
October 28, 1981	Letter from NRC Counsel to Atomic Safety and Licensing Board providing preliminary notification concerning recent development involving containment building annulus region.
October 30, 1981	Letter from Governor of California to NRC Chairman requesting independent audit of earthquake protection and other safety-related features.
November 2, 1981	Board Notification 81-35 forwarding licensee's letter of October 23, 1981 and PNO-V-81-59.

November 3, 1981	Meeting with licensee to discuss progress of licensee's re-evaluation of potential seismic error of containment annulus area.
November 3, 1981	Letter from licensee to NRC Region V transmitting draft of plan for seismic reverification program by R. L. Cloud.
November 4, 1981	Board Notification 81-36 forwarding PNO-V-81-54 and licensee's letters dated October 19 and 27, 1981.
November 4, 1981	Board Notification 81-37 forwarding transcript of November 3, 1981, meeting.
November 5, 1981	Board Notification 81-38 forwarding report submitted by licensee on seismic reverification program.
November 6, 1981	Letter from licensee to NRC Chairman objecting to October 30 request from Governor of California.
November 6, 1981	Letter from NRC Region V to licensee transmitting inspection report associated with seismic design errors.
November 9, 1981	Commission meeting on recent seismic design errors.
November 13, 1981	Letter from licensee regarding additional work requirements for review of seismic analysis.
November 13, 1981	Letter from licensee transmitting first biweekly status report for the seismic review.
November 16, 1981	Board Notification 81-39 transmitting meeting minutes dated May 18, 1967, on trenching conducted at site.
November 16, 1981	Letter from Governor of California to NRC Chairman providing comments on November 9 staff briefing to Commission.
November 16, 1981	Commission meeting on discussion of May 18, 1967 memo and seismic reverification plan.
November 18, 1981	Letter from licensee to NRC Region V transmitting preliminary report on seismic reverification program prepared by R. L. Cloud.
November 19, 1981	Issuance of Commission Order (CLI-81-30) suspending Facility Operating License No. DPR-76.
November 19, 1981	Letter to licensee requesting independent design verification programs be performed.
November 20, 1981	Letter from licensee transmitting dead-load drawings to supplement the November 13 biweekly status report.

November 20, 1981	Letter from Commissioner Gilinsky advising of visits to NRC Region V Office and R. L. Cloud's office to discuss reverification efforts.
November 25, 1981	Letter from licensee transmitting semi-monthly status report No. 2.
November 25, 1981	Letter from licensee to NRC Region V transmitting Supplement 2 to Licensee Event Report 81-002.
November 30, 1981	Letter from NRC General Counsel to Governor of California in response to October 30 letter.
November 30, 1981	Letter from NRC General Counsel to licensee in response to November 6 and 13 letters.
December 4, 1981	Letter from licensee transmitting "Qualifications of Companies Proposed to Conduct Independent Reviews," "Design Verification Program Seismic Service Related Contacts Prior to June 1978," and "Overall Verification Program of the Diablo Canyon Power Plant."
December 7, 1981	Letter from Teledyne to licensee discussing proposal for independent design verification program.
December 10, 1981	Letters to Governor of California and Joint Intervenors regarding reverification program.
December 11, 1981	Board Notification 81-47 issued on the potential deficiency in the seismic analysis of equipment and components in the containment annulus.
December 11, 1981	Letter from licensee transmitting semi-monthly status report No. 3.
December 14, 1981	Board Notification 81-51 regarding recent information in regard to the emergency preparedness plan.
December 16, 1981	Letter to licensee (Generic Letter 81-40) issued on qualifications of reactor operators, license examinations.
December 17, 1981	Board Notification 81-54 issued on potential deficiency in the seismic analysis of equipment and components in the containment annulus.
December 17, 1981	Letter from Governor of California to NRC Chairman and Commissioners requesting halt of audit being performed.
December 18, 1981	Letter from licensee to Region V transmitting Supplement 3 to Licensee Event Report 81-002.
December 22, 1981	Letter from licensee concerning ongoing audit.

December 22, 1981	Letter from licensee regarding December 17 letter from Governor of California.
December 23, 1981	NRC letter and Order regarding reverification program plan and company selection.
December 23, 1981	Letter from NRC Region V to licensee requesting copies of all documents related to R. L. Cloud interim draft report.
December 24, 1981	Letter from licensee transmitting semi-monthly status report No. 4.
December 30, 1981	Letter from NRC Region V to licensee requesting licensee to direct R. L. Cloud to provide information relating to investigation of independence.
January 8, 1982	Letter from licensee transmitting semi-monthly status report No. 5.
January 8, 1982	Letter from licensee to NRC Region V clarifying intent of November 18, 1982 submittal.
January 8, 1982	Letter from licensee advising that no response is required to November 19, 1981, submittal of draft report on reverification program, since final report will provide complete results of reverification program.
January 8, 1982	Letter from NRC Region V to licensee providing preliminary notification that design reverification study reveals potential discrepancy in seismic design basis for auxiliary building.
January 11, 1982	Letter from licensee to NRC Region V transmitting Supplement 4 to Licensee Event Report 81-002.
January 11, 1982	Letter from licensee to NRC Region V transmitting information in response to December 23 letter.
January 13, 1982	Letter from licensee transmitting Phase II program description: (1) "Design Verification Program for Power Ascension" and (2) "Qualification Document Design Verification Program for Power Ascension Diablo Canyon Power Plant Unit 1, Pacific Gas and Electric Company," Volumes 1, 2, and 3.
January 15, 1982	Letter from Governor of California to NRC Chairman requesting halt of reverification program.
January 15, 1982	Letter from licensee transmitting five structural drawings presented at October 14-16, 1981 meeting.
January 18, 1982	NRC Region V report on investigation of licensee's reviews and comments on draft report of results of R. L. Cloud study.

January 19, 1982	Letter from licensee regarding press release by Governor of California concerning reverification program.
January 21, 1982	Board Notification 82-05 issued on information item on potential deficiency in the seismic analysis of equipment and components in the containment annulus of Diablo Canyon Unit 1 (transmitting PNO-V-82-03).
January 22, 1982	Letter from licensee advising of submittal date for semi-monthly status report No. 6.
January 22, 1982	Letter from licensee transmitting data for two piping seismic analyses.
January 25, 1982	Letter from licensee transmitting semi-monthly status report No. 6.
January 25, 1982	Letter from license to NRC Region V transmitting Supplement 5 to Licensee Event Report 81-002.
January 27, 1982	Board Notification 82-06 issued on information item on applicant's January 13 submittal of design verification program, Phase II for Diablo Canyon Unit 1.
January 27, 1982	Letter from NRC Region V transmitting report on investigation of activities associated with the preparation and submittal of R. L. Cloud Phase I Program.
January 28, 1982	Letter to licensee requesting additional information to determine acceptability of program plan.
January 28, 1982	Letter to licensee concerning the proposed Reverification Program Plan.
February 2, 1982	Letter from Joint Intervenors to NRC Chairman expressing concern regarding reverification program.
February 2, 1982	Letter to licensee concerning comment period for Phase II of design verification program.
February 3, 1982	Meeting with licensee, R. L. Cloud, and R. F. Reedy to discuss issues based on staff review of December 4 submittal.
February 5, 1982	Letter from Teledyne regarding design reverification program.
February 5, 1982	Letter from Joint Intervenors to NRC Commissioners transmitting comments on results of staff's investigation of relationship between licensee and R. L. Cloud.
February 8, 1982	Board Notification 82-11 regarding potential deficiency in the seismic analysis of equipment and components in the containment annulus of Diablo Canyon Unit 1 (transmitting trip report of February 3, 1981).

February 10, 1982	Statement of the Commission directing issuance of Notice of Violation.
February 10, 1982	Letter from NRC Region V to licensee regarding investigation of activities associated with preparation and submittal of information on verification program.
February 10, 1982	Letter from Teledyne to licensee transmitting responses on independence.
February 10, 1982	Letter from R. L. Cloud licensee forwarding review team qualifications, task assignments, conflict of interest statements, and transcript corrections for minutes of February 3, 1982, meeting.
February 1982	Issuance of NRC Inspection Report, "Preliminary Report, Seismic Reverification Program" at Diablo Canyon Power Plant Units 1 and 2, Phase II Program (NUREG-0862).
February 11, 1982	Letter from R. L. Cloud transmitting answers to certain questions raised in the February 3 meeting.
February 11, 1982	Letter to licensee transmitting the notice of violation on a material false statement.
February 11, 1982	R. L. Cloud's seventh progress report on the seismic reverification program.
February 11, 1982	Letter from R. L. Cloud transmitting the technical qualifications of review team.
February 11, 1982	Letter from licensee to NRC Region V adding G. N. Horne, VP - Public Relations, to the November 3, 1981, meeting attendants list.
February 12, 1982	Letter from R. L. Cloud requesting clarification of certain sections of NUREG-0862.
February 12, 1982	Letter from licensee transmitting the semi-monthly status report No. 7.
February 17, 1982	Meeting with Governor of California and Joint Intervenors to discuss licensee's submittal of December 4.
February 19, 1982	Board Notification 82-14 issued on information item on potential deficiency in the seismic analysis of equipment and components in the containment annulus of Diablo Canyon Unit 1 (transmitting meeting summary and other data from February 3, 1982, meeting).
February 20, 1982	Letter from licensee transmitting corrections to transcript of February 3 meeting transcript.

February 23, 1982	Board Notification 82-16 transmitting February 10 and 11 letters from R. L. Cloud on Design Verification Program for Diablo Canyon Unit 1.
February 23, 1982	Letter from R. L. Cloud advising that project has escalated to about 60-70% of recent billings.
February 26, 1982	Letter from licensee transmitting the semi-monthly status report No. 8.
February 26, 1982	Letter from R. L. Cloud transmitting the eighth progress report on the seismic reverification program.
February 26, 1982	Letter from Joint Intervenors objecting to Teledyne as the independent auditor.
February 27, 1982	Letter from R. L. Cloud listing service-safety-related contractors identified to date and transmitting "Seismic Reverification Program - RLCA - Sample Selection."
February 27, 1982	Letter from R. L. Cloud clarifying two issues raised by the February 3, 1982, meeting.
March 1, 1982	Letter from R. L. Cloud transmitting Revision 1 of R. L. Cloud's Phase I of Design Verification Program.
March 1, 1982	Letter from NRC Region V to licensee transmitting inspection report with one violation in engineering quality control.
March 1, 1982	Letter from R. F. Reedy transmitting quality assurance review report of Cygna Energy Services and ANCO.
March 2, 1982	Letter from licensee transmitting information submitted by Teledyne.
March 3, 1982	Board Notification 82-19 forwarding transcript of February 17 meeting with representatives of Governor of California and of Joint Intervenors.
March 4, 1982	Letter from NRC Office of the Secretary to counsel for the parties in the Diablo Canyon seismic proceeding transmitting a report dated January 27, 1982, on Diablo Canyon-Newmark Inquiry.
March 4, 1982	Commission meeting on staff recommendations in Diablo Canyon program plan and independence of audit.
March 5, 1982	Letter to licensee, Governor of California, and Joint Intervenors announcing the Commission's acceptance of the staff's recommendation of the seismic design verification Phase I program and requesting list of proposed contractors for design verification program.

March 8, 1982	Letter from R. F. Reedy transmitting licensee's audit and review report.
March 8, 1982	Letter from Teledyne suggesting that it is the logical selection as program manager for design verification program.
March 9, 1982	Letter from licensee forwarding status report on seismically induced systems interaction program.
March 10, 1982	Board Notification 82-23 transmitting report of trip (February 22-26, 1982) regarding seismic design verification.
March 12, 1982	Letter from R. L. Cloud advising that ninth progress report will be issued March 15, 1982.
March 12, 1982	Letter from licensee proposing Teledyne as the independent auditor.
March 12, 1982	Letter from NRC Office of the Secretary transmitting further remarks of NRC Chairman relating to Commission Order CLI-32-1.
March 12, 1982	Letter from licensee transmitting ninth semimonthly status report.
March 15, 1982	Letter from R. L. Cloud transmitting ninth progress report.
March 15, 1982	Board Notification 82-24 transmitting March 8 submittal by Teledyne Engineering Services regarding seismic verification program - Phase I for Diablo Canyon Unit 1.
March 15, 1982	Board Notification 82-25 transmitting submittals from R. L. Cloud dated February 11, 26, 27, and March 1 regarding the seismic verification program.
March 15, 1982	Board Notification 82-26 transmitting two March 1, March 5, and March 8 submittals by R. F. Reedy regarding the seismic verification program.
March 15, 1982	Letter from licensee forwarding data and drawings for structural analyses of Unit 1, and forwarding modeling parameters for Unit 2 containment interior structure.
March 15, 1982	Letter from licensee in response to Notice of Violation EA-82-13.
March 18, 1982	Letter from licensee in response to March 4 letter from NRC Office of the Secretary.
March 18, 1982	Letter from NRC Office of the Secretary advising that petitions for review of ASLB-644 decision have been denied.

March 19, 1982	Letter from licensee to Teledyne transmitting preliminary comments on program management plan, Revision 0.
March 19, 1982	Letter to licensee advising that staff has approved Teledyne as independent company to conduct design verification program, Phase I, with list of issues to be considered.
March 23, 1982	Letter from licensee transmitting Teledyne statements regarding potential or apparent conflicts of interest.
March 23, 1982	Letter from licensee transmitting an intracompany letter dated March 22, 1982, reemphasizing licensee's commitment to full and open communication between licensee, its contractors, and the NRC.
March 23, 1982	Letter from Joint Intervenors to Advisory Committee on Reactor Safeguards (ACRS) Chairman requesting the ACRS to reopen its consideration of Diablo Canyon's seismic design.
March 23, 1983	Letter from R. L. Cloud transmitting 10th progress report.
March 24, 1982	Board Notification 82-29 transmitting March 1 and 15 submittals by R. F. Reedy and R. L. Cloud regarding the design verification program, Phase I, for Diablo Canyon Unit 1.
March 25, 1982	Meeting with licensee to discuss organizational structure for the design verification program, Phases I and II, and to discuss issues pertaining to revisions of the Phase I program.
March 29, 1982	Letter from R. L. Cloud forwarding R. F. Reedy's portion of 10th progress report.
March 30, 1982	Letter from licensee transmitting 10th semi-monthly status report.
March 30, 1982	Letter from R. L. Cloud advising of project manager for verification program.
March 31, 1982	Letter from licensee concerning adequacy of the pressurizer safety and relief valves.
March 31, 1982	Letter from NRC Region V transmitting Inspection Report of activities associated with seismic reverification program.
April 1, 1982	Meeting with licensee to discuss staff questions pertaining to the quality assurance (QA) audit reviews performed by R. F. Reedy.
April 2, 1982	Letter from Teledyne transmitting Independent Verification Design Program: Phase I, Program Management Plan.

April 2, 1982	Board Notification 82-33 issued on the seismic verification program.
April 2, 1983	Board Notification 82-34 issued on the seismic verification program (transmitting transcript of March 25, 1982, meeting).
April 5, 1982	Letter from Teledyne forwarding draft of Independent Design Verification Program: Potential or Apparent Conflicts of Interest of Individuals.
April 6, 1982	Letter from licensee to ACRS opposing Joint Intervenors letter of March 23, 1983.
April 6, 1983	Notice of Abnormal Occurrence issued on seismic design errors at Diablo Canyon Nuclear Power Plant.
April 6, 1982	Letter from licensee transmitting revised Overall Management Plan.
April 6, 1982	Letter from licensee in response to request to describe how previous Teledyne work for IE Bulletin 79-02 would be reviewed under the design verification program.
April 8, 1982	Letter from licensee transmitting piping schematics in connection with request for relief from certain inservice inspection requirements.
April 8, 1982	Letter to licensee transmitting Phase I Program Management Plan.
April 9, 1982	Letter from licensee transmitting 11th semi-monthly status report.
April 9, 1982	Letter from R. L. Cloud transmitting 11th progress report on the seismic verification program.
April 10, 1982	Letter from Teledyne transmitting a draft Independent Design Verification Program, Program Procedure: Potential or Apparent Conflicts of Interest of Individuals.
April 10, 1982	Letter from Teledyne transmitting 11th semi-monthly status report.
April 12, 1982	Letter from Teledyne requesting information regarding Phase II of Independent Design Verification Program.
April 12, 1982	Letter from Teledyne concerning initiation of QA reviews and "design chain" actions.
April 12, 1982	Letter from R. F. Reedy transmitting 11th semi-monthly progress report.
April 12, 1982	Board Notification 82-36 issued on the seismic verification program, transmitting transcript of April 1, 1982, meeting.

April 13, 1982	Letter from Teledyne transmitting revisions to transcripts of meetings held March 25 and April 1.
April 13, 1982	Letter to licensee in response to its request to withdraw or alter February 11 Notice of Violation.
April 13, 1982	Letter to licensee requesting complete computer listing of input and output of vertical seismic analysis.
April 15, 1982	Letter from licensee forwarding comments on March 8, 1982, R. F. Reedy report on QA.
April 15, 1982	Letter from licensee in response to April 13 letter.
April 15, 1982	Letter from licensee providing comments on R. F. Reedy's review of licensee's pre-1978 QA program.
April 16, 1982	Letter from Teledyne advising of temporary project manager.
April 20, 1982	Letter to licensee transmitting NRC inspection report on design verification program modifications.
April 21, 1982	Letter to Joint Intervenors responding to letter dated March 23, 1982, and transmitting requested documents regarding ALAB-644.
April 22, 1982	Letter from licensee forwarding announcement and organization chart integrating Bechtel's resources.
April 23, 1982	Letter from licensee transmitting 12th semi-monthly status report.
April 23, 1982	Letter from R. L. Cloud transmitting 12th progress report.
April 23, 1982	Letter from Teledyne transmitting 12th semi-monthly status report.
April 26, 1982	Board Notification 82-42 transmitting April 10 Teledyne letter; April 9 R. L. Cloud letter, and April 8 R. F. Reedy letter.
April 26, 1982	Letter from Teledyne transmitting new cover sheet for 12th semi-monthly status report.
April 26, 1982	Letter from licensee transmitting printout of input and output data of vertical seismic analysis.
April 26, 1982	Letter from NRC Chairman to California Seismic Safety Commission regarding its concern about implications of recent seismic design errors at Diablo.
April 27, 1982	Letter to licensee advising of approval of Teledyne Phase I plan.

April 27, 1982	Letter from R. F. Reedy transmitting R. F. Reedy progress report No. 12 on QA audit and review of IDVP.
April 27, 1982	Letter from R. F. Reedy recommending changes to the minutes of meeting held on April 1, 1982.
April 27, 1982	Letter from NRC Office of the Secretary concluding the investigation of whether Dr. N. Newmark had been employed by licensee for the Diablo Canyon Project.
April 28, 1982	Letter from licensee to NRC Region V regarding violations noted in Inspection Report 50-275/82-07 and advising of corrective actions.
April 28, 1982	Letter from licensee transmitting piping schematics drawings.
April 30, 1982	Meeting with licensee to hear explanation of role that Bechtel will assume in completion of project.
April 30, 1982	Letter from Governor of California expressing concern with two matters discussed at recent meeting.
April 30, 1982	Board Notification 82-44 issued on the design verification program transmitting April 23 letters from Teledyne and R. L. Cloud and April 27 letter from R. F. Reedy.
May 7, 1982	Letter from Teledyne to licensee transmitting additional statements regarding potential or apparent conflicts of interest.
May 12, 1982	Letter from Joint Intervenors requesting issuance of order to show cause.
May 13, 1982	Letter from Governor of California to ASLB requesting the Board to direct licensee to provide information on implications of errors identified in Board Notification PNO-5-82-09 and IE Information Notice 82-11.
May 14, 1982	Letter from licensee transmitting the 13th semi-monthly status report.
May 14, 1982	Letter from R. L. Cloud transmitting 13th progress report.
May 14, 1982	Letter from Teledyne transmitting 13th semi-monthly status report.
May 14, 1982	Letter from R. F. Reedy transmitting 13th semi-monthly progress report.
May 18, 1982	Letter to licensee summarizing April 30, 1982, meeting on the discussion of role of Bechtel Power Corporation in completion of the Diablo Canyon Project.

May 23, 1982	Letter from Teledyne discussing the designation of a civil structure consultant.
May 24, 1982	Letter from NRC Region V to licensee transmitting Inspection Reports 50-275/50-323/82-08.
May 24, 1982	Board Notification 82-51 issued on the design verification program May 14 letters from Teledyne, R. L. Cloud, and R. F. Reedy.
May 25, 1982	Letter from licensee replying to Governor of California's motion regarding Board Notification PNO-5-82-09 and IE Information Notice 82-11.
May 25, 1982	Letter from Joint Intervenors discussing licensee's proposed license amendment related to project reorganization.
May 25-26, 1982	Audit conducted by NRC at Teledyne Engineering Services on IDVP.
May 26, 1982	Letter from R. L. Cloud transmitting progress report No. 14 on the IDVP.
May 27, 1982	Letter from NRC Region V to licensee transmitting NRC Inspection Report 50-275/82-17 on IDVP meeting on May 15, 1982.
May 28, 1982	Letter from licensee transmitting 14th semi-monthly status report.
May 28, 1982	Letter from Teledyne transmitting 14th semi-monthly status report.
May 28, 1982	Letter from R. F. Reedy transmitting progress report No. 14 on the QA audit and review of the IDVP.
May 28, 1982	Letter from Joint Intervenors discussing the ongoing design verification program conducted by Teledyne.
May 28, 1982	Letter from Teledyne advising of designation of civil structural consultant.
May 28, 1982	Letter from Teledyne advising of temporary project manager.
June 2, 1982	Board Notification 82-53 issued on the design verification program (transmitting summary of April 30th meeting).
June 9, 1982	Letter from Joint Intervenors to ASLAB requesting reopening of record.
June 9, 1982	Letter from R. L. Cloud transmitting 15th progress report.

June 9, 1982	Letter from R. L. Cloud transmitting first "Interim Technical Report on Additional Verification and Additional Sampling."
June 9, 1982	Board Notification 82-57 issued on the design verification program.
June 10, 1982	Meeting with licensee and Teledyne to discuss status of design verification program efforts, including schedules and QA program.
June 11, 1982	Letter from licensee transmitting final report on pipe supports base plate design.
June 11, 1982	Letter from licensee transmitting 15th semi-monthly status report.
June 11, 1982	Letter from Teledyne transmitting 15th semi-monthly status report.
June 11, 1982	Letter from licensee responding to Joint Intervenors' request for action pursuant to 10 CFR 2.206(a) dated May 12, 1982.
June 11, 1982	Letter from R. F. Reedy transmitting 15th semi-monthly status report.
June 14, 1982	Letter from NRC Region V to licensee transmitting Inspection Reports 50-275/82-16 and 50-323/82-09 on modifications to piping and electrical supports resulting from the revised annulus spectra.
June 14, 1982	ASLB Memorandum and Order denying California Governor's motion of May 13, 1982.
June 15, 1982	Letter from NRC Region V to licensee transmitting Inspection Report 50-275/82-18 on general employee training, chemistry, and radiation protection staff training, NUREG-0737 conditions.
June 16, 1982	Letter to Joint Intervenors acknowledging the receipt of their petition requesting NRC to issue a show cause order to PG&E why it should not be required to submit an amendment to its operating license.
June 18, 1982	Letter from licensee transmitting Bechtel Quality Assurance Program.
June 18, 1982	Letter from Teledyne forwarding Independent Design Verification, Phase II, Program Management Plan and Phase II, Engineering Plan.

June 18, 1982	Board Notification 82-60 issued on the design verification program, Phase I, transmitting June 11 Teledyne letter, June 9 R. L. Cloud letter, and June 14 R. F. Reedy letter.
June 18, 1982	Board Notification 82-61 issued on information items regarding the design verification program, Phase I.
June 23, 1982	Letter from R. L. Cloud transmitting 16th progress report.
June 24, 1982	Letter from Teledyne transmitting second Phase I Interim Technical Report.
June 24, 1982	Letter from Teledyne discussing transmittal of its Program Management Plan, Phase II to Joint Intervenors.
June 25, 1982	Letter from licensee transmitting 16th semi-monthly status report.
June 25, 1982	Letter from Teledyne transmitting 16th semi-monthly report.
June 28, 1982	Letter from Teledyne advising of error in Interim Technical Report on QA.
June 29, 1982	Letter from NRC Region V transmitting NRC Inspection Reports 50-275/82-20 and 50-323/82-10 on implementation of verification program.
June 29, 1982	Board Notification 82-62 issued on allegations concerning the Diablo Canyon Nuclear Power Plant.
June 30, 1982	Letter from R. F. Reedy transmitting 16th semi-monthly status report.
July 1, 1982	Board Notification 82-66 issued on the design verification program, transmitting letters from Teledyne and the licensee dated June 18.
July 1, 1982	Board Notification 82-67 forwarding Brookhaven report on its independent evaluation of Diablo Canyon design verification.
July 1, 1982	Letter to Teledyne transmitting Brookhaven Report, "Independent Seismic Evaluation of the Diablo Canyon Unit 1 Containment Annulus Structure and Selected Piping Systems."
July 1, 1982	Board Notification 82-68 issued on the design verification program transmitting letter from Teledyne dated June 24.
July 2, 1982	Board Notification 82-69 issued on the design verification program.
July 2, 1982	Licensee response to Joint Intervenor's motion to reopen record.

July 2, 1982	Response by Governor of California regarding Joint Intervenor's motion to reopen record.
July 3, 1982	Letter from Teledyne transmitting Revision 1 to Phase I Program Management Plan.
July 7, 1982	NRC Counsel response to Joint Intervenor's motion to reopen record.
July 7, 1982	Letter from licensee forwarding response to Joint Intervenor's motion to reopen record.
July 8, 1982	Letter from licensee to Teledyne regarding report by Brookhaven.
July 8, 1982	Letter from Teledyne advising of receipt of Brookhaven report on containment annulus structure and selected piping systems.
July 8, 1982	Letter to Joint Intervenors transmitting Teledyne letter of June 18, 1982.
July 8, 1982	Letter to Governor of California transmitting Teledyne letter of June 18, 1982.
July 8, 1982	Letter from Stone & Webster advising that there are no open item reports for reporting period ending July 9.
July 9, 1982	Letter from R. F. Reedy transmitting semi-monthly progress report No: 17.
July 9, 1982	Letter from R. L. Cloud forwarding semi-monthly progress report No. 17.
July 9, 1982	Letter from Teledyne forwarding semi-monthly progress report.
July 9, 1982	Letter from licensee transmitting 17th semi-monthly status report.
July 16, 1982	Letter from R. L. Cloud transmitting Interim Technical Report on tanks (Rev. 0).
July 16, 1982	Letter from Teledyne transmitting correction to July semi-monthly report.
July 22, 1982	Board Notification 82-76 transmitting June 28 Teledyne letter, June 30 R. F. Reedy letter, July 7 Teledyne letter, and July 9 Teledyne and R. L. Reedy letters.
July 23, 1982	Letter from licensee transmitting 18th semi-monthly status report.

July 23, 1983	R. L. Cloud's Interim Technical Report on shake table testing, Rev. 0.
July 26, 1982	Letter from R. F. Reedy, issuing semi-monthly report No. 18.
July 27, 1982	Letter from Teledyne transmitting semi-monthly report No. 18.
July 27, 1982	Letter from NRC Region V to licensee transmitting Inspection Reports 50-275/82-22 and 50-323/82-11.
July 27, 1982	Meeting with licensee, Brookhaven (BNL), and Teledyne to exchange information and provide clarification regarding BNL report.
July 29, 1982	Letter from Teledyne transmitting revision to semi-monthly report.
July 29, 1982	Letter from R. F. Reedy retracting semi-monthly report for July.
July 29, 1082	Board Notification 82-72 issued on information item with regard to Region IV investigation at Teledyne.
July 29, 1982	Letter from Teledyne advising of temporary project manager.
July 30, 1982	Commission Order releasing non-safeguard information of ALAB-653.
August 2, 1982	Board Notification 82-80 issued on information item regarding the design verification program, Phase I, forwarding R. L. Cloud letter of July 16.
August 2, 1982	Letter from Joint Intervenors to Commission regarding Phase II Program Management Plan issued by Teledyne.
August 2, 1982	Letter from Governor of California transmitting comments concerning proposed Phase II Management Plan.
August 2, 1982	Letter to licensee forwarding comments on QA program.
August 3, 1982	Letter from licensee requesting 1-year extension of expiration date of Facility Operating License No. DPR-76.
August 5, 1982	Letter from Teledyne forwarding program procedure for interface between IDVP participants and the licensee.
August 6, 1982	Meeting with licensee and Teledyne regarding current scope and status of the internal technical program, the relationship of the program to the IDVP, and of the schedule for the verification program; Teledyne discussed current status and scope of IDVP.
August 11, 1982	Letter to Brookhaven forwarding items requested by Teledyne.

August 12, 1982	Letter from Stone & Webster advising that it has issued no open item reports since July semi-monthly report.
August 12, 1982	Board Notification 82-85 issued on the design verification program, Phase I, for Diablo Canyon Unit 1 transmitting trip report for May 25-26; R. L. Cloud letter dated July 23; Teledyne letter dated July 29 and transcript of July 27 meeting.
August 13, 1982	Letter from licensee forwarding information on quality assurance program in response to August 2 request.
August 13, 1982	Letter from Teledyne transmitting Open Item Report System Forms (semi-monthly report).
August 13, 1982	Letter from R. F. Reedy consisting of semi-monthly reports No. 18.
August 13, 1982	Letter from licensee transmitting 19th semi-monthly status report.
August 13, 1982	Letter from R. L. Cloud transmitting reports issued during August semi-monthly reporting period.
August 17, 1982	Board Notification 82-86 issued on the design verification program (transmitting July 7 letter from Control Data to NRC).
August 19, 1982	Letter to Teledyne requesting additional information on IDVP.
August 19, 1982	Letter to licensee requesting information on Internal Technical Program.
August 19, 1982	Letter from R. L. Cloud transmitting Interim Technical Report on the Design Chain.
August 20, 1982	Letter from licensee transmitting preliminary outline for Final Report for Phase I of design verification program.
August 24, 1982	Letter from R. L. Cloud concerning allegations regarding preparation of preliminary report of seismic verification program.
August 24, 1982	Letter from licensee providing lists of systems and equipment required for initial fuel loading and those systems and equipment that will provide operational support during initial fuel load.
August 25, 1982	Board Notification 82-89 transmitting transcript of August 6 meeting.
August 27, 1982	Letter from licensee transmitting 20th semi-monthly status report.

August 27, 1982	Letter from licensee concerning future changes in Technical Specifications (regarding snubbers) due to verification program.
August 27, 1982	Letter from Teledyne forwarding preliminary response to August 19 letter.
August 27, 1982	Letter from Teledyne transmitting semi-monthly status report.
August 31, 1982	ASLB Initial Decision authorizing full-power license.
September 1, 1982	Letter from licensee transmitting portions of Design Verification Program Phase I Final Report.
September 1, 1982	Meeting with licensee and IDVP contractors to discuss activities within the PG&E Internal Technical Program, including corrective actions, Phase I Final Report and status, integrated project schedule, and QA program, and to discuss status of the IDVP Phase I and Phase II.
September 1, 1982	Letter from licensee providing information on corrective action program and schedule.
September 3, 1982	Board Notification 82-91 issued on design verification program - Phase I (transmitting August 13 letters from Teledyne, R. L. Cloud, and R. F. Reedy, Stone & Webster letter of August 12, and R. L. Cloud letter of August 19.
September 7, 1982	Letter from licensee advising that Teledyne will conduct programmatic review of construction QA program as part of Phase II.
September 8, 1982	Letter from licensee transmitting listing of systems and equipment required for low temperature testing.
September 8, 1982	Letter from licensee providing information on open items identified by the Internal Technical Program.
September 8, 1982	Letter to Teledyne advising of the acceptability of its procedure for ensuring the independence of individuals assigned to IDVP.
September 9, 1982	Meeting with representatives of Joint Intervenors and Governor of California to discuss the IDVP Phase II plan, and the PG&E corrective action program.
September 10, 1982	Letter from R. L. Cloud transmitting revision to reports for September semi-monthly reporting period.
September 10, 1982	Letter from licensee transmitting 21st semi-monthly status report.
September 10, 1982	Letter from Teledyne transmitting semi-monthly status report.

September 10, 1982	Letter from R. F. Reedy consisting of semi-monthly progress report No. 19.
September 10, 1982	Letter from Stone & Webster forwarding September semi-monthly report.
September 10, 1982	Letter from R. L. Cloud submitting Interim Technical Report, Diablo Canyon Unit 1 Independent Design Verification Program, Auxiliary Building, Revision 0.
September 13, 1982	Letter from Teledyne transmitting semi-monthly status report.
September 13, 1982	Letter from Teledyne transmitting Revision 4 to September semi-monthly status report.
September 14, 1982	Letter from Teledyne transmitting corrections to transcript of September 1 meeting.
September 14, 1982	Board Notification 82-95, transmitting Teledyne letter of August 27 and transcript of September meeting with licensee and Teledyne.
September 14, 1982	Letter from licensee responding to Institute of Nuclear Power Operations Nuclear Plant Construction Quality Evaluation Program.
September 15, 1982	Letter from licensee forwarding responses to requests made at September 1 and 9 meetings.
September 17, 1982	Letter from Teledyne transmitting IDVP Program Procedure, "Potential or Apparent Conflicts of Interest of Individuals," Revision 1.
September 17, 1982	Letter from NRC Region V to licensee transmitting NRC Inspection Reports 50-275/82-26 and 50-323/82-13.
September 17, 1982	Letter from Teledyne transmitting Program Procedure Piping Support Baseplate and Anchor Bolt Evaluation, Revision 1.
September 17, 1982	Letter from R. L. Cloud transmitting Interim Technical Report No. 7 on Raceway Supports, Revision 0.
September 17, 1982	Letter from licensee tramsmitting additional sections of the Phase I Final Report on turbine building and HVAC ducts and supports.
September 22, 1982	Issuance of Director's Decision and Notice (re Joint Intervenor's request).
September 24, 1982	Teledyne's Program Plan Rev. 0 - Adjunct Program for Evaluation of Construction Quality Assurance.

September 24, 1982	Letter from licensee transmitting 22nd semi-monthly status report.
September 24, 1982	Letter from Teledyne transmitting semi-monthly status report.
September 24, 1982	Memorandum to Commission on Diablo Canyon design verification program.
September 25, 1982	Letter from Teledyne transmitting Program Plan for Construction Quality Assurance.
September 29, 1982	Letter from Teledyne transmitting revised procedure on conflict of interest.
September 29, 1982	Board Notification 82-100, transmitting Teledyne September 13 letter; R. F. Reedy, R. L. Cloud, and Stone & Webster, September 10 letters, Teledyne and R. L. Cloud September 17 letters).
September 29, 1982	Letter from Teledyne requesting program manual used for piping analysis.
September 29, 1982	Letter to Teledyne concerning independence of Teledyne and the need and desire to maintain communication.
October 1, 1982	Letter from licensee transmitting sections of Phase I Final Report, "Blume Internal Review (BIR): Independent Internal Reviews of Work Done by LRS/Blume Engineers on Diablo Canyon Nuclear Power Plant," and Revision 3 of outline for Phase I Final Report.
October 5, 1982	Letter from Teledyne transmitting Program Plan for Construction Quality Assurance, Revision 1.
October 5, 1982	Letter from R. L. Cloud transmitting Interim Technical Report on the Corrective Action Plan, Revision 0.
October 5, 1982	Letter to Teledyne regarding request for specific information items regarding Brookhaven Report.
October 6, 1982	Board Notification 82-101 issued on R. F. Reedy Phase II QA Audits.
October 6, 1982	Letter from Teledyne forwarding preliminary responses from program participants and subcontractors.
October 6, 1982	Board Notification 82-102 issued on the design verification program Phase I for Diablo (transmitting Teledyne letters of September 24 and 25).
October 6, 1982	Letter from R. L. Cloud transmitting Interim Technical Report, on the Corrective Action Plan, Rev. 0.

October 6, 1982	Letter to Teledyne requesting preparation of assessment of basic cause of design errors, which are to be included in final IDVP reports for Phases I and II.
October 6, 1982	Letter from R. L. Cloud transmitting program manager preface to interim technical report.
October 6, 1982	Letter to Teledyne forwarding summary of meeting and comments for QA audit.
October 7, 1982	Letter from Teledyne transmitting IDVP integrated (RLCA and TES) review comments to September 1, 1982 PG&E Phase I Report.
October 8, 1982	Letter from licensee transmitting 23rd semi-monthly status report.
October 8, 1982	Letter from R. L. Cloud advising that no Open Item Reports were issued during prior reporting period.
October 8, 1982	Letter from Teledyne forwarding Open Item Report System Forms issued by TES since September 10 report.
October 8, 1982	Letter from Stone & Webster transmitting semi-monthly report.
October 8, 1982	Letter from R. F. Reedy consisting of semi-monthly report No. 20.
October 11, 1982	Letter from Bechtel advising that Bechtel is not owned by Teledyne, R. L. Cloud, Stone & Webster, or any of their subcontractors, and that Bechtel holds no financial interest in any of those firms.
October 12, 1982	Letter from Teledyne providing clarification of request for "views" on required systems, structures, and components for plant operating modes.
October 13, 1982	Board Notification 82-104 transmitting R. L. Cloud letter of October 5.
October 13, 1982	Commission Paper SECY 82-414 issued on Diablo Canyon Design Verification Program, Phase II Recommendations.
October 14, 1982	Letter from NRC Region V to licensee transmitting Inspection Reports 50-275/82-30 and 50-323/82-14.
October 14, 1982	Letter from Teledyne regarding employment of two former Bechtel employees.
October 15, 1982	Letter from Teledyne providing responses to Region V comments on Phase II activities.
October 15, 1982	Letter from licensee transmitting additional sections of Design Verification - Phase I Final Report on fuel handling

	building, intake structure, mechanical equipment, electrical conduit and raceway supports review.
October 15, 1982	Letter from Teledyne in response to October 6 letter request.
October 15, 1982	Letter from Teledyne providing preliminary response to July 1 letter that transmitted Brookhaven report.
October 15, 1982	Letter from R. F. Reedy transmitting Interim Technical Report (ITR-9) on development of safety-related contractor list for nonseismic work.
October 19, 1982	Meeting with licensee and IDVP contractors to discuss status of IDVP Phase I and Phase II issues.
October 20, 1982	Commission meeting on proposed scope of Phase II of verification program.
October 21, 1982	Meeting with licensee and independent design verification program members to discuss CONTEMPT computer code.
October 22, 1982	Letter from licensee transmitting 24th semi-monthly status report.
October 22, 1982	Letter from Teledyne transmitting semi-monthly status report for October.
October 22, 1982	Letter from Teledyne providing clarification of transcript of October 19 meeting.
October 22, 1982	Letter from R. L. Cloud transmitting Revision 1 to Interim Technical Report on Additional Verification and Additional Sampling.
October 25-26, 1982	Site visit and meeting with Bechtel regarding structures and equipment evaluated by Brookhaven.
October 26, 1982	Board Notification 82-109, transmitting Teledyne IDVP dated October 1; Teledyne IDVP Comments on Phase I Final Report, dated October 7; Teledyne, R. L. Cloud, R. F. Reedy, and Stone & Webster reports of October 8; and Teledyne letters of October 6, 12, 14, and 15 (2 letters).
October 27, 1982	Letter to licensee transmitting (under separate cover) information sent to Teledyne on October 5.
October 29, 1982	R. L. Cloud's Interim Technical Report No. 10 on Design Analysis Hosgri Spectra, Rev. 0.
November 1, 1982	Board Notification 82-110 issued on the design verification program, Phase I, transcript of October 19 meeting.
November 1, 1982	Letter from Teledyne advising of replacement of assistant project manager.

November 1, 1982	Board Notification 82-112 issued on forwarding the Design Verification Program (transmitting R. F. Reedy letter of October 15, Teledyne letters of October 12 and 22, and R. L. Cloud letter of October 27).
November 1, 1982	Letter from licensee transmitting additional portions of Phase I Final Report (Parts 2 and 3, sections on auxiliary. building, large bore piping and supports, HVAC design review, Phase I management plan and program reports).
November 2, 1982	Teledyne's Interim Technical Report: PG&E-Westinghouse Seismic Interface Review, Rev. 0.
November 3, 1982	Letter from Teledyne transmitting 11th Phase I Interim Technical Report.
November 3, 1982	Letter to Teledyne forwarding results of review of Interim Technical Reports 1 - 5.
November 4, 1982	Letter from NRC Chairman to R. L. Cloud in response to August 24 letter.
November 5, 1982	Letter from R. L. Cloud transmitting Open Item Reports issued during reporting period.
November 5, 1982	Letter from R. L. Cloud transmitting Interim Technical Report No. 12 on Piping, Revision 0.
November 5, 1982	Letter from R. L. Cloud transmitting Interim Technical Report No. 13 on Soils-Intake Structure, Rev. 0.
November 6, 1982	Letter from Teledyne transmitting IDVP Program Procedure DCNPP-IDVP-PP-007, Rev. 1.
November 10, 1982	Meeting to discuss comments on Phase II Reverification Program.
November 10, 1982	Letter from licensee to NRC Office of Secretary transmitting comments on October 20 meeting.
November 12, 1982	Letter from Teledyne providing clarification of PP-007, Revision 1, regarding interface between IDVP participants and other parties.
November 12, 1982	Letter from Stone & Webster forwarding Open Item Report Forms issued on construction quality assurance evaluation.
November 12, 1982	Letter from Stone & Webster transmitting semi-monthly report.
November 12, 1982	Letter from R. F. Reedy transmitting semi-monthly progress report No. 21.
November 12, 1982	Letter from licensee transmitting 25th semi-monthly report.

November 12, 1982	Letter from Teledyne transmitting semi-monthly report.
November 15, 1982	Letter from NRC Region V to licensee transmitting Inspection Report 50-275/82-31.
November 16, 1982	Board Notification 82-119 issued on the design verification program (transmitting Reedy letter of October 15, R. L. Cloud letters of October 19 and November 5, and Teledyne letter of November 3).
November 18, 1982	Letter from Teledyne transmitting list of additional names and addresses for inclusion in Rev. 1 to Procedure DCNPP-IDVP-PP-007.
November 19, 1982	Letter from licensee transmitting additional sections of Phase I Final Report on intake structure, small bore piping, small bore pipe supports and instrumentation tubing and tubing supports.
November 22, 1982	Letter from Stone & Webster transmitting notes of conference for November 4 working meeting.
November 24, 1982	Board Notification 82-105 issued on alleged design deficiency.
November 24, 1982	Letter from licensee transmitting 26th semi-monthly report
November 24, 1982	Board Notification 82-120 issued on the design verification program.
November 26, 1982	Letter from Teledyne forwarding "IDVP Semimonthly Report for November 1982."
November 26, 1982	Letter from NRC Region V to licensee transmitting Inspection Report 50-275/82-35.
November 29, 1982	Letter from Stone & Webster forwarding documentation regarding load profile calculations.
November 29, 1982	Letter from Teledyne advising of revised personnel assignments.
December 1, 1982	Letter to licensee concerning independent analyses to be performed by Brookhaven National Laboratory.
December 2, 1982	Letter from licensee forwarding schedules for fuel loading, low-power testing, and full-power license.
December 2, 1982	Letter to licensee requesting clarification on which QA program will be applied to what specific project activities.
December 3, 1982	Letter from Teledyne requesting additional information on Brookhaven analysis of containment annulus structure.

December 3, 1982	Letter from licensee requesting restoration of low power license and stepwise licensing schedule to full power.
December 6, 1982	Letter from Teledyne advising of IDVP concurrence with licensee request for restoration of low-power license and stepwise licensing schedule to full power.
December 6, 1982	Board Notification 82-127 issued on the design verification program.
December 8, 1982	Letter to Governor of California regarding recommendation for independent analyses by Brookhaven National Laboratory on seismic qualification of turbine building.
December 8, 1982	Board Notification 82-128 issued on the design verification program .
December 8, 1982	Letter from R. L. Cloud transmitting Interim Technical Report 16 on Soils-Outdoor Water Storage Tanks, Revision 0.
December 8, 1982	Commission meeting on Phase II reverification program.
December 10, 1982	Letter from licensee forwarding information on structural analysis for use by Brookhaven.
December 10, 1982	Letter from Stone & Webster transmitting "Verification of Pressure Temperature, Humidity and Submergency Environ Used in Safety-Related Equipment," ITR 14, Rev. 0.
December 10, 1982	R. L. CLoud Interim Technical Report No. 15 on HVAC duct and supports.
December 10, 1982	Letter from Teledyne transmitting December semi-monthly report.
December 10, 1982	Letter from licensee transmitting 27th semi-monthly status report.
December 10, 1982	Letter from R. F. Reedy transmitting semi-monthly progress report No. 22.
December 13, 1982	Letter from licensee concerning relief and safety valve test requirements.
December 13, 1982	Letter from R. L. Cloud transmitting Interim Technical Report 15 on HVAC Duct and Duct Supports, Rev. 0.
December 15, 1982	Letter from R. L. Cloud transmitting Interim Technical Report 17 on Piping; Additional Samples.
December 15, 1982	Letter from Stone & Webster transmitting "Verification of Fire Protection Provided for Auxiliary Feedwater System

Control Room Ventilation and Pressurization System, Safety-Related Portion of 4160-Volt Electrical System," Interim Technical Report 18, Revision 0.

December 17, 1982	Letter from licensee forwarding information needed by Brookhaven.
December 17, 1982	Letter from licensee forwarding additional sections of Phase I Final Report on outdoor storage tanks, mechanical equipment, electrical equipment, and instrumentation and HVAC equipment.
December 20, 1982	Letter from Stone & Webster transmitting Interim Technical Reports 19, 20, 21, and 22.
December 20, 1982	Letter from Teledyne transmitting summary of its December 2 meeting.
December 21, 1982	Letter from licensee transmitting Revision 2 to Quality Assurance Program.
December 21, 1982	Meeting with licensee and Brookhaven; licensee to provide clarification and discuss the information provided by licensee for Brookhaven containment annulus horizontal seismic analysis.
December 22, 1982	Board Notification 82-132 issued on the design verification program, Phase I.
December 23, 1982	Letter from Stone & Webster transmitting Interim Technical Reports 24, 25, and 26 on electrical distribution system design review and auxiliary feedwater system electrical design.
December 23, 1982	Letter from licensee transmitting 28th semi-monthly status report.
December 23, 1982	Letter from Teledyne transmitting draft Interim Technical Report, Phase II Additional Samples and Verification.
December 23, 1982	Commission Memorandum and Order issued.
December 24, 1982	Letter from Teledyne transmitting semi-monthly status report.
December 28, 1982	Letter to licensee concerning two-step licensing approach.
December 30, 1982	Board Notification 82-138 issued on the design verification program.
December 30, 1982	Letter from Stone & Webster transmitting Interim Technical Reports 17 and 18 regarding verification of I&C design of auxiliary feedwater system and control room ventilation and pressurization system.

January 1, 1983	Letter from licensee providing information in response to December 1 letter.
January 4, 1983	Letter from licensee transmsitting part of information requested December 1 and transmitting information Brookhaven requested at December 21 meeting.
January 7, 1983	Board Notification 83-03 issued on notification of seismic qualification allegations.
January 7, 1983	Letter to Teledyne transmitting response by Brookhaven to letter dated December 3, 1982.
January 7, 1983	Letter to Teledyne transmitting response by Brookhaven to request for information.
January 12, 1983	Letter from R. L. Cloud transmitting Interim Technical Report 30 on small bore piping.
January 13, 1983	Board Notification 83-05 issued on the design verification program.
January 14, 1983	Letter from Teledyne transmitting semi-monthly report.
January 14, 1983	Letter from licensee transmitting 29th semi-monthly report.
January 14, 1983	Letters (2) from Stone & Webster advising of no open item reports issued since December semi-monthly report.
January 14, 1983	Letter from R. L. Cloud transmitting several Open Item Reports.
January 14, 1983	Letter from R. F. Reedy transmitting semi-monthly progress report.
January 17, 1983	Letter from R. L. Cloud transmitting Interim Technical Report 31 on HVAC components.
January 18, 1983	Letter from Teledyne regarding additional sample and additional verification.
January 18, 1983	Letter from Teledyne reporting on status of IDVP civil/structural efforts.
January 19, 1983	Letter to Teledyne transmitting meeting transcript on alleged safety deficiencies.
January 19, 1983	Letter to licensee requesting information on pressure and temperature profiles for pipe break outside containment.
January 20, 1983	Letter from Stone & Webster transmitting Interim Technical Report No. 29, "Design Chain - Initial Sample."

January 21, 1983	Letter from licensee transmitting additional sections of Part 2 of Phase I Final Report.
January 26, 1983	Letter to licensee advising of acceptability of Revisions 1 and 2 of QA program.
January 26, 1983	Letter to licensee regarding information items needed by Brookhaven to perform analyses.
January 28, 1983	Letter from licensee transmitting 30th semi-monthly report.
February 3, 1983	Letter from Teledyne advising of new Lead Nuclear Technology Engineer.
February 3, 1983	Board Notification 83-10 transmitting Stone & Webster letter of January 20, Teledyne letter dated January 28, and transcript of January 28 meeting.
February 4, 1983	Teledyne meeting with licensee, NRC staff, and Brookhaven to discuss status of containment annulus steelwork and status of auxiliary building.
February 4, 1983	Letter from licensee forwarding information regarding Brookhaven information requests.
February 4, 1983	Letter from licensee forwarding information on pressure/temperature profile analysis.
February 7, 1983	Letter from Stone & Webster transmitting "Verification of Diablo Canyon Project Efforts by Stone & Webster Engineering Corporation," Interim Technical Report 34.
February 8, 1983	Letter from Teledyne forwarding voided cover sheet for TES EP-1-007.
February 9, 1983	Letter from NRC Region V transmitting Inspection Reports 50-275/83-02 and 50-323/83-01.
February 10, 1983	Letter to licensee transmitting letter from Brookhaven requesting additional information for buried oil storage tank study.
February 11, 1983	Letter from licensee transmitting 31st semi-monthly report.
February 11, 1983	Letters (2) from Stone & Webster advising of no open item reports issued since January semi-monthly report.
February 11, 1983	Letter from licensee forwarding information requested by Brookhaven on February 4.
February 11, 1983	Letter from Teledyne transmitting semi-monthly status report.

February 11, 1983	Letter from NRC Region V transmitting Inspection Reports 50-275/83-04 and 50-323/83-03.
February 11, 1983	Letter from R. L. Cloud transmitting semi-monthly report.
February 14, 1983	Meeting with Brookhaven on status of seismic analysis efforts.
February 16, 1983	Letter from R. F. Reedy consisting of semi-monthly progress report No. 24.
February 16, 1983	Letter from Brookhaven regarding PG&E Problem 8-118 and Westinghouse problem RHR Loop 4.
February 17, 1983	Letter from licensee transmitting sections and tables in Part 2 of Phase I Final Report.
February 17, 1983	Letter from R. L. Cloud transmitting Interim Technical Report 32 on Pumps, Revision 0.
February 18, 1983	Letter from licensee revising scheduled submittal date for Phase II Status Report.
February 18, 1983	Letter form R. L. Cloud transmitting Interim Technical Report 33 on Electrical Equipment Analysis, Revision 0.
February 18, 1983	Letter from Teledyne requesting information for containment annulus structure analysis.
February 23, 1983	Letter from R. L. Cloud transmitting Interim Technical Report 37 on Valves, Revision 0.
February 23, 1983	Board Notification 83-22 transmitting letters from Teledyne dated January 18 (2 letters), and February 11, R. F. Reedy (undated), letters from Stone & Webster dated February 7 and 11 (2 letters), trip report of January 26 meeting, transcript of February 15 meeting, and trip report of February 4 meeting.
February 24, 1983	Letter from Teledyne advising of change in submittal date for next semi-monthly report.
February 24, 1983	Letter from Brookhaven listing items needing clarification on RHR Loop 4 and Problem 8-118 Piping.
February 24-25, 1983	Teledyne meeting with licensee, R. L. Cloud, and NRC staff to discuss structural review.
February 25, 1983	Letter from licensee transmitting 32nd semi-monthly status report.
February 25, 1983	Letter from licensee forwarding pressure and temperature data for pipe break outside containment.

February 25, 1983	Letter to licensee transmitting Brookhaven requests dated February 16 and 24.
February 25, 1983	Letter from R. L. Cloud transmitting Interim Technical Report 39 on Soils Intake Structure Bearing Capacity and Lateral Earth Pressure, Revision 0.
March 2, 1983	Letter from licensee transmitting changes to schedule for fuel loading, low power testing, and full power operation.
March 2, 1983	Letter from Teledyne transmitting semi-monthly status report.
March 2, 1983	Letter from licensee transmitting information requested by Brookhaven.
March 3, 1983	Letter from Stone & Webster forwarding Interim Technical Reports No. 36, Revision 0, "Final Report on Construction Quality Assurance Evaluation of Guy F. Atkinson Company," and No. 38, Revision 0, "Construction Quality Assurance Evaluation of Wismer & Becker."
March 3, 1983	Board Notification 83-30 issued on changes to fuel loading schedule.
March 4, 1983	Letter from licensee transmitting FLUD 6 computer code steam blowdown input data necessary to calculate pressure and temperature transients in areas GE/GW of the auxiliary building.
March 10, 1983	Letter from NRC Region V to licensee transmitting Inspection Report 50-275/83-05 and 50-323/83-04.
March 10, 1983	Letter from R. L. Cloud forwarding Open Item Reports for March.
March 10, 1983	Letter from R. L. Cloud transmitting Interim Technical Report 40 on Soils-Intake Structure Sliding Resistance.
March 11, 1983	Letter from Teledyne transmitting semi-monthly status report.
March 11, 1983	Letter from licensee transmitting Phase II Status Report.
March 11, 1983	Letter from licensee transmitting 32nd semi-monthly status report.
March 11, 1983	Letter from Stone & Webster, advising that no Open Item Report issued on construction QA since February report.
March 11, 1983	Letter from Stone & Webster consisting of March semi-monthly report.

March 15, 1983	Letter from licensee transmitting additional information on buildings, structures, and supports for Part 2 of Phase I Final Report.
March 16, 1983	Letter from R. F. Reedy transmitting semi-monthly progress report No. 25.
March 18, 1983	Board Notification 83-35 transmitting R. F. Reedy letters of February 16 and 18, R. L. Cloud letters of February 17, 18, 23, and 25, Teledyne letter of March 2, and Stone & Webster letters of March 3 (two letters).
March 18, 1983	Letter from Stone & Webster transmitting Interim Technical Report 38, Revision 1, "Final Report on Construction Quality Assurance Evaluation of Wismer & Becker."
March 18, 1983	Letter from licensee forwarding piping information requested by Brookhaven.
March 22, 1983	Letter from licensee advising that final temperature and pressure versus time curves will be sent by April 11.
March 25, 1983	Letter from licensee forwarding information in response to Brookhaven request for information on diesel fuel oil storage tanks.
March 25, 1983	Letter from Teledyne transmitting semi-monthly status report.
March 25, 1983	Letter from licensee transmitting 34th semi-monthly status report.
March 25, 1983	Letter from Teledyne clarifying distribution of interim semi-monthly status report.
March 28, 1983	Letter from Stone & Webster transmitting Interim Technical Report 34, Revision 1, "Verification of Diablo Canyon Project Efforts by Stone and Webster Engineering Corporation."
March 29, 1983	Letter from NRC Region V to licensee transmitting Inspection Reports 50-275/83-08 and 50-323/83-07.
March 29, 1983	Board Notification 83-41 issued on the design verification program.
April 1, 1983	Letter from R. L. Cloud transmitting Interim Technical Report 32 on Pumps, Revision 1.
April 1, 1983	Letter from R. L. Cloud transmitting Interim Technical Report 35, "IDVP Verification Plan for Diablo Canyon Project Activities," Revision 0.

April 4, 1983	Board Notification 83-48 issued on allegations regarding Diablo Canyon.
April 6, 1983	Board Notification 83-49 transmitting March 25 letter from Teledyne.
April 8, 1983	Letter from R. L. Cloud transmitting several Open Item Reports.
April 8, 1983	Letter from licensee transmitting 35th semi-monthly status report.
April 8, 1983	Letter from Teledyne transmitting semi-monthly status report.
April 8, 1983	Letter from Teledyne transmitting "Interface Between IDVP and Participants, DCP, and Designated Other Parties," Revision 2.
April 8, 1983	Letter from Stone & Webster advising that no Open Item Reports issued since last semi-monthly report.
April 11, 1983	Letter from Brookhaven transmitting analysis of piping systems.
April 12, 1983	Letter from California Dept. of Justice transmitting statements by V. Tennyson and R. Roam.
April 13, 1983	Letter from R. F. Reedy advising that no Open Item Reports issued during reporting period.
April 13, 1983	Letter from licensee transmitting pressure and temperature transient analysis reports related to pipe breaks outside containment.
April 13, 1983	Letter from licensee transmitting drawings of annulus steel structure design.
April 14, 1983	Letter from R. L. Cloud transmitting "Independent Design Verification Program, Heat Exchangers."
April 15, 1983	Letter from R. F. Reedy transmitting Interim Technical Report No. 42 on design consultants.
April 15, 1983	Board Notification 83-50 issued on the design verification program.
April 15, 1983	Letter from licensee regarding anonymous allegations on structural adequacy, requesting opportunity to respond.
April 15, 1983	Letter from R. L. Cloud transmitting Interim Technical Report No. 43 on heat exchangers.

April 18, 1983	Letter from R. L. Cloud transmitting Interim Technical Report 44 on shake table test mounting of Class IE electrical equipment.
April 21, 1983	Letter to Joint Intervenors regarding recent transmittal of anonymous allegations.
April 21, 1983	Appeal Board Memorandum and Order issued stating that record will be reopened on design quality assurance matters.
April 22, 1983	Letter from licensee transmitting 36th semi-monthly status report.
April 22, 1983	Letter from Teledyne transmitting semi-monthly status report.
April 22, 1983	Letter from R. E. Reedy forwarding "Corrective Action Program and Design Office Verification," ITR 41, Revision 0.
April 22, 1983	Letter from licensee transmitting additional information for Parts 1 and 2 of Phase I Final Report.
April 25, 1983	Letter from Stone & Webster transmitting "Verification of the Mechanical/Nuclear Design of the Control Room Ventilation and Pressurization System," ITR 20, Revision 1, and "Verification of the Mechanical/Nuclear Portion of the Auxiliary Feedwater System," ITR 22, Revision 1.
April 27-28, 1983	Teledyne meeting with NRC staff, R. L. Cloud, and DCP to discuss status of all structures.
April 28, 1983	Letter from Joint Intervenors regarding meeting with NRC to discuss anonymous allegations.
April 29, 1983	Letter from R. L. Cloud transmitting ITR 33, Revision 1, on electrical equipment analysis.
May 2, 1983	Letter to Cooper providing comments on ITR 36, Revision 0 and ITR 38, Revision 1k.
May 2, 1983	Letter from Teledyne transmitting IDVP Final Report, Initial Text Submittal.
May 3, 1983	Letter from NRC Region V to licensee transmitting Inspection Reports 50-275/83-15 and 50-323/83-12.
May 3, 1983	Letter from Joint Intervenors regarding anonymous allegations.
May 3, 1983	Board Notification 83-56 issued on the design verification program.
May 4, 1983	Letter from Stone & Webster transmitting "Verification of the Auxiliary Feedwater System Electrical Design," ITR 25,

Revision 1, and "Verification of the Control Room Ventilation and Pressurization System Electrical Design, ITR 26, Revision 1.

May 4, 1983	Meeting with licensee to discuss status of design verification program and licensee's evaluation of eight recent allegations by an anonymous individual.
May 4, 1983	Board Notification 83-61 issued on the design verification program.
May 5, 1983	Board Notification 83-55 issued on allegations regarding construction quality assurance.
May 9, 1983	Letter from licensee forwarding information on pressure/temperature analysis for pipe break outside containment.
May 9, 1983	Letter from Stone & Webster transmitting "Verification of the Effects of High Energy Line Cracks and Moderate Energy Line Breaks for Auxiliary Feedwater System and Control Room Ventilation and Pressurization System," ITR 21, Revision 1, and "Verification of the 4160 V Safety-Related Electrical Distribution System," ITR 24, Revision 1.
May 11, 1983	Board Notification 83-65 issued on the design verification program.
May 12, 1983	Letter from Stone & Webster transmitting "Verification of the Pressure, Temperature, Humidity and Submergence Environments Used for Safety-Related Equipment Specification Outside Containment for Auxiliary Feedwater System and Control Room Ventilation and Pressurization System," ITR 14, Revision 1.
May 12, 1983	Board Notification 83-68 issued on the design verification program (transmitting Final Report by Teledyne).
May 13, 1983	Letter from Stone & Webster advising that no Open Item Reports issued since last semi-monthly report.
May 13, 1983	Letter from licensee transmitting 37th semi-monthly status report.
May 13, 1983	Letter from Teledyne transmitting semi-monthly status report.
May 13, 1983	Letter from R. L. Cloud transmitting two Open Item Reports.
May 16, 1983	Letter from Teledyne transmitting second text submittal of IDVP Final Report.
May 17, 1983	Letter from Brookhaven regarding its analysis of horizontal response of annulus structure to the Hosgri seismic input.

May 18, 1983 — Letter from licensee transmitting updated sections of Phase I Final Report concerning fuel handling and turbine buildings, large-bore and small-bore piping and HVAC equipment results.

May 18, 1983 — Board Notification 83-69 issued on the Design Verification Program.

May 18, 1983 — Appeal Board Decision (ALAB-728) issued.

May 18, 1983 — Letter from Stone & Webster transmitting ITR 17, "Verification of the Instrument and Control Design of the Auxiliary Feedwater System."

May 18, 1983 — Letter from licensee transmitting updated sections of Phase I Final Report.

May 18, 1983 — Letter from Stone & Webster transmitting ITR 28, Revision 1, "Verification of the Instrument and Control Design of the Control Room Ventilation and Pressurization System."

May 20, 1983 — Letter from Teledyne transmitting Revision 3 of IDVP Program Procedure, "Interface Between IDVP Participants, DCP, and Designated Other Parties."

May 20, 1983 — Meeting with licensee and Westinghouse to discuss seismic qualification of Main Control Board.

May 20, 1983 — Letter from Stone & Webster transmitting ITR 45, "Additional Verification of Redundancy of Equipment and Power Supplies in Shared Safety-Related Systems."

May 25, 1983 — Letter from Joint Intervenors regarding recent news report in San Luis Obispo County Telegram-Tribune.

May 26, 1983 — Letter from Stone & Webster transmitting ITR 18, Rev. 1, "Verification of the Fire Protection Provided for Auxiliary Feedwater System, Control Room Ventilation and Pressurization System, Safety-Related Portion of the 4160 V Electric System."

May 27, 1983 — Letter from licensee transmitting 38th semi-monthly status report.

May 27, 1983 — Board Notification 83-76 issued on the design verification program.

May 27, 1983 — Letter from Teledyne transmitting preliminary drafts of "Final Report on Construction QA Evaluation of G. F. Atkinson Company," ITR 36, Rev. 1, and "Final Report on Construction QA Evaluation of Wismer & Becker," ITR 38, Rev. 2.

May 27, 1983	Letter from Teledyne transmitting semi-monthly status report.
May 31, 1983	Memorandum to Commission issued on the Status of Diablo Canyon Design Verification Effort.
May 31, 1983	Letter from Teledyne transmitting third text submittal of final report, "Diablo Canyon Nuclear Power Plant Unit 1 Independent Design Verification Program."
June 2, 1983	Letter from Stone & Webster transmitting ITR 23, Revision 1, "Verification of High Energy Line Break and Internally Generated Missile Review Outside Containment for Auxiliary Feedwater System and Control Room Ventilation and Pressurization System."
June 2, 1983	Teledyne meeting with licensee to discuss various items.
June 3, 1983	Board Notification 83-77 issued on allegation concerning release of draft NRC report.
June 3, 1983	Letter to Joint Intervenors regarding potential pre-release of NRC report.
June 3, 1983	Letter from Teledyne regarding IDVP review and position on DCP reevaluation of Diablo turbine building and intake structure.
June 9, 1983	Letter from licensee regarding recent newspaper articles on welding deficiencies.
June 10, 1983	Board Notification 83-78 issued on the design verification effort.
June 10, 1983	Letter from Teledyne transmitting semi-monthly report.
June 10, 1983	Board Notification 83-78 transmitting Stone & Webster May 18 letter, Trip Reports of May 13 and May 16, Stone & Webster May 20 letter, transcripts of May 20 and May 21 meetings.
June 10, 1983	Letter from R. L. Cloud transmitting several Open Item Reports.
June 10, 1983	Letter from licensee transmitting 39th semi-monthly status report.
June 10, 1983	Letter from Stone & Webster transmitting June semi-monthly report.
June 10, 1983	Letter from licensee regarding proposed FSAR revision on Quality Assurance.

June 13, 1983	Letter from Teledyne to Appeal Board regarding corrections for Interim Technical Reports 36 and 38.
June 13, 1983	Letter from licensee transmitting "Phase II Final Report, Design Verification Program."
June 13, 1983	Letter from Teledyne transmitting corrected pages for draft Interim Technical Reports 36 and 38.
June 15, 1983	Letter from Teledyne forwarding fourth text submittal of Phase I Final Report.
June 15, 1983	Meeting with Teledyne to discuss auxiliary building structures and polar crane/rail effort.
June 17, 1983	Meeting with licensee and Brookhaven. Brookhaven discussed and presented results of its seismic analysis of buried tanks.
June 20, 1983	Letter from Stone & Webster transmitting "Independent Design Verification Program, Final Report on Construction QA Evaluation of Wismer & Becker," ITR 38, Rev. 2.
June 20, 1983	Letter from Teledyne transmitting Errata 2 to Final Report.
June 20, 1983	Board Notification 83-73 issued on Information Items regarding Potentially Inadequate Welds in Component Cooling Water Piping System (licensee letter dated May 9 and Preliminary Notification dated May 10).
June 20, 1983	Board Notification 83-80 issued on Information Items regarding the design verification program (transmitting Brookhaven letter of May 17, letter from T. Bishop (Region V) of May 19, Stone & Webster letter of May 26, and Teledyne letters of May 27, May 31 and June 2.
June 21, 1983	Letter from licensee transmitting final installment of Phase I Final Report.
June 21, 1983	Letter to Teledyne regarding review of Interim Technical Reports 13, 39, and 40.
June 22, 1983	Letter to licensee requesting information addressing eight allegations concerning design verification effort.
June 22, 1983	Letter from Teledyne transmitting 5th Text Submittal of IDVP Final Report.
June 22, 1983	Letter from Teledyne transmitting Revision 3 to Final Report.

June 23, 1983	Letter from licensee forwarding revised schedule for completion of activities required for fuel loading, low-power testing, and full-power authorization.
June 23, 1983	Letter from Joint Intervenors expressing concern regarding independence of verification effort.
June 24, 1983	Board Notification 83-83 issued on Notice of Violation Concerning Reporting Requirements.
June 24, 1983	Letter from Stone & Webster transmitting "Final Report on Construction Quality Assurance Evaluation of Guy F. Atkinson Company," ITR 36, Rev. 1, and "Final Report on Construction Quality Assurance Evaluation of Wismer & Becker," ITR 38, Rev. 2.
June 24, 1983	Board Notification 83-86 issued on Information Items Regarding the Design Verification Program (Stone & Webster letter of June 10, R. L. Cloud letter of June 10, and Teledyne letter of June 10.
June 24, 1983	Letter from Teledyne transmitting June semi-monthly status report.
June 24, 1983	Letter from licensee transmitting 40th semi-monthly status report.
June 24, 1983	Letter from licensee transmitting report, "Supplement on As-Builts."
June 28, 1983	Letter from Teledyne transmitting sixth text submittal for Final Report.
June 29, 1983	Board Notification 83-89 issued on additional information regarding Potential Violation re: Wall Thickness.
June 29, 1983	Letter from Teledyne regarding June 22 meeting with DCP.
June 30, 1983	Letter from Stone & Webster transmitting Interim Technical Reports 46, 47, and 49 on system design pressure, pipe ruptures, and circuit separation.
June 30, 1983	Letter from Teledyne transmitting seventh text submittal of Final Report.

APPENDIX D

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Supplement No. 18 to the Safety Evaluation Report for Pacific Gas and Electric Company's application for licenses to operate the Diablo Canyon Nuclear Power Plant (Docket Nos. 50-275 and 50-323), located in San Luis Obispo County, California, has been prepared by the Office of Nuclear Reactor Regulation of the U.S. Nuclear Regulatory Commission. This supplement presents the staff's evaluation on matters related to a verification effort on Diablo Canyon Unit 1 that was the result of Commission Order CLI-81-30 and a letter to Pacific Gas and Electric Company, dated November 19, 1981.

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