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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING APPEAL BOARD

In the Matter of PACIFIC GAS AND ELECTRIC CO. (Diablo Canyon Nuclear Power Plant, Unit Nos. 1 and 2	Docket Nos. 50-275 O.L. 50-323 O.L.

TESTIMONY OF RICHARD B. HUBBARD
REGARDING DESIGN QUALITY ASSURANCE

I. INTRODUCTION

Q: Please state your name, address, and occupation.

A: My name is Richard B. Hubbard, and my business address is 1723 Hamilton Avenue, San Jose, California. I am vice-president of MHB Technical Associates.

Q: Which of your qualifications and experience are relevant to the design quality assurance (QA) matters you address in this testimony?

A: I am a Professional Quality Engineer licensed by the State of California (license number QU 805). I hold a B.S. in Electrical Engineering from the University of Arizona (1960) and an M.B.A. from the University of Santa Clara (1969). I have nineteen years' experience in the design and manufacture of systems and equipment for nuclear power generation facilities, including eleven years' experience in responsible engineering and manufacturing managerial positions in the

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Nuclear Instrumentation Department (1965-1971), Atomic Power Equipment Department (1971-1975), and Nuclear Energy Control and Instrumentation Department (1975-1976) of the General Electric Company (GE). For the past seven years, I, along with my co-founders of MHB Technical Associates, have conducted numerous studies pertaining to the safety, quality, reliability, and economic aspects of nuclear power facilities.

From November 1971 to February 1976, I was a Manager of Quality Assurance for the manufacturing operations at the San Jose, California, headquarters of GE's Nuclear Energy Division. I was responsible for the development and implementation of quality plans, programs, methods, and equipment to assure that equipment for nuclear plants designed, manufactured and procured by General Electric met quality requirements as defined in NRC regulation 10 C.F.R. Part 50, Appendix B ("Appendix B"); ASME Boiler and Pressure Vessel Code; customer contracts; and GE corporate policies and procedures. The product areas include radiation sensors, reactor vessel internals, fuel handling and servicing tools, nuclear plant control and protection instrumentation systems, and control room panels for the Nuclear Steam Supply System (NSSS) and Balance of Plant (BOP). I was responsible for approximately 45 exempt personnel, 22 non-exempt personnel, and 129 hourly personnel with a yearly expense budget of nearly 4 million dollars and an equipment investment budget of approximately 1.2 million dollars. While employed by General Electric, I was responsible for developing a quality system which received NRC certification in 1975. The QA system was also successfully surveyed for ASME "N" and "NPT" symbol authorizations in 1972 and 1975, plus ASME "U" and "S" symbol authorizations in 1975. I was also responsible for the quality assurance program and its implementation at GE's spare and renewal parts warehouse in San Jose. I am a member of the IEEE Nuclear Power Engineering Standards Subcommittee responsible for the preparation and revision of a number of Quality Assurance standards for safety-related aspects of nuclear power facilities.

Finally I have testified on safety-related aspects of nuclear power facilities' quality assurance programs as an expert witness before the NRC Licensing Boards; before and at the request of the NRC's Advisory Committee on Reactor Safeguards; before the Joint Committee on Atomic Energy of the United States Congress; and before various other federal and state legislative and administrative bodies. A summary of my experience and professional qualifications is set forth in the affidavit of qualifications that is being filed with this testimony.

Q: What sources of information have you relied upon in preparing this testimony?

A: The facts and conclusions set forth in this testimony are generally based upon the information served on the parties in the ongoing Diablo Canyon Nuclear Power Station, Units 1 and 2 (Diablo Canyon), licensing proceedings that I have received and reviewed between September 1981 and September 1983 in my continuing role as technical consultant to counsel for the Governor of California in these proceedings. I have reviewed the semi-monthly status reports provided by Pacific Gas and Electric Company (PG&E) and Teledyne Engineering Services (TES) concerning the Independent Design Verification Program (IDVP). Further, I have reviewed the Interim Technical Reports (ITRs) issued by TES. In addition, I have reviewed the IDVP Final Report and the Phase I and Phase II reports released by the Diablo Canyon Project (DCP) resulting from its Internal Technical Program (ITP). I have prepared and submitted to the NRC detailed comments concerning inadequacies in the proposed scope and methodology of the Phase I and Phase II verification programs. I have discussed these technical comments at the meetings between Mr. Denton of the NRC Staff and the intervenors in the Diablo Canyon proceedings in San Francisco on February 17, 1982, and September 9, 1982. In addition, I attended and made a presentation on these matters to the NRC commissioners at a meeting in Washington, D.C., on November 10, 1982. I participated in a number of meetings between the various participants in the Diablo Canyon QA/QC investigations, including on-site and off-site meetings with personnel from PG&E, TES, NRC, Bechtel, Stone and Webster Engineering (S&W), Robert L. Cloud Associates (RLCA), Roger Reedy Incorporated (Reedy), and Brookhaven National Laboratory (BNL). Finally, I am familiar with the PG&E license commitments set forth in the Diablo Canyon Final Safety Analysis Report (FSAR) and the

NRC staff reviews as documented in the Safety Evaluation Report (SER) and its supplements, including Supplements 16 and 18 regarding the staff's most recent reviews of the plant design.

II. PURPOSE

Q: What is the purpose of your testimony?

A: The purpose of my testimony is to address the level of assurance provided by the Diablo Canyon design verification program conducted by the IDVP and ITP. Specifically, this testimony addresses the matters set forth in Contentions 5, 6, 7, and 8.

Q: How is your testimony organized?

A: Part III of the testimony provides an overview of design quality assurance. Terms utilized in the testimony are defined and key assumptions are identified. My evaluation of the matters encompassed by Contentions 5, 6, 7, and 8 are set forth in Parts IV through VII of the testimony respectively. First, my assessment of the effectiveness of the ITP's design configuration control efforts to assure that the as-built Diablo Canyon plant conforms to the design documents is delineated in Part IV. In Part V, the failure of the verification program (i.e., the IDVP and the ITP) to reverify a suitable sample of the design services subcontracted to Westinghouse by PG&E is presented. The necessity for identifying all the root causes which led to or provided the basis for design errors discovered by the IDVP and ITP is described in Part VI of the testimony, while in Part VII the adequacy of the ITP's quality assurance measures applied to the design modifications developed since November 1, 1981, is reviewed. Finally, the conclusions resulting from my review are summarized in Part VIII.

III. OVERVIEW OF QUALITY ASSURANCE/QUALITY CONTROL

Q: This testimony is about quality assurance. How is "quality assurance" defined?

A: Appendix B uses the term "quality assurance" (QA) to comprise "all those planned and systematic actions necessary to provide adequate confidence that a structure, system, or component will perform satisfactorily in service."

Q: What does "quality control" (QC) mean?

A: Appendix B states that "Quality assurance includes quality control, which comprises those quality assurance actions related to the physical characteristics of a material, structure, component or system which provide a means to control the quality of the materials, structure, component, or system to predetermined requirements."

Q: What is "engineering assurance"?

A: Engineering assurance is a term often used to describe the quality program measures applied by engineering to its design control activities. For example, the Chief, Engineering Quality Control, develops and maintains the PG&E Engineering Department quality control program.[1]

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1. Diablo Canyon FSAR, page 17.1-7.

Q: Does the preceding mean that not all QA program elements required by the 18 criteria of Appendix B are necessarily conducted by personnel of the QA organization?

A: Yes. For instance, design verification is normally conducted by members of the design organization, i.e., the originating engineer and the reviewing engineer. Other examples of QA measures often not conducted by the QA organization include procurement, special process specification and qualification, document distribution and records maintenance, control of measuring and test equipment, and handling and storage of material and equipment. In such cases, the QA organization normally provides surveillance inspections and audits of the organization performing the quality activity.

Q: What is an "audit"?

A: "Audit" is defined in ANSI Standard N45.2.12 as

> "A documented activity performed in accordance with written procedures or checklists to verify, by examination and evaluation of objective evidence, that applicable elements of the quality assurance program have been developed, documented and effectively implemented in accordance with specified requirements. An audit should not be confused with surveillance or inspection for the sole purpose of process control or product acceptance."

In general there are three major types of nuclear plant design audits as follows:

(a) Program audit - an audit whose purpose is to compare the design QA program to the applicable regulatory requirements and Safety Analysis Report (SAR) commitments.

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(b) Process audit - an audit whose purpose is to ascertain whether the existing design control procedures are functioning properly and are being effectively implemented.

(c) Product audit - an audit of the design documents whose purpose is to demonstrate that the design documents such as specifications and drawings correctly reflect the applicable regulatory requirements and the design basis commitments set forth in the SAR.

Criterion 18 of Appendix B ("Audits") requires that a comprehensive system of planned and periodic audits be carried out to verify compliance with all aspects of the quality assurance program and to determine the effectiveness of the program. Thus, audits are intended to identify conditions adverse to quality so that they can be corrected and similar repetitive deficiencies precluded in the future.

Q: What is an "error"?

A: In this testimony the term "error" will be utilized consistent with the definitions adopted by the IDVP in Appendix F of the Final Report as follows:

> Error: A form of program resolution of an Open Item indicating an incorrect result that was verified as such. It may have been due to a mathematical mistake, use of a wrong analytical method, omission of data or use of inapplicable data. Each Error was classified as the most appropriate of the following:
>
> (a) Error Class A: Design criteria or operating limits of safety related equipment were exceeded and, as a result, physical modifications or changes in operating procedures were required. . . .

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(b) Error Class B: An Error was considered Class B if design criteria or operating limits of safety related equipment were exceeded, but were resolvable by means of more realistic calculations or retesting. . . .

(c) Error Class C: Incorrect engineering or installation of safety related equipment was found, but no design criteria or operating limits were exceeded. No physical modifications were required. . . .

Q: What is an Error Class AB?

A: On a number of occasions, the IDVP could not determine whether resolution would or would not require physical modifications, so the terminology Error Class A or B (ER/AB) was used.

Q: Did the IDVP also identify a category of discrepancies it categorized as a "deviation"?

A: Yes. The IDVP defined a deviation as follows:

> Deviation: A departure from standard procedure which is not a mistake in analysis, design, or construction. No physical modifications are required. . . .

Q: Will you use the term "deviation" in your testimony?

A: No. In my judgment the term "deviation" cannot be precisely differentiated from an "Error C." Consequently, contrary to the IDVP definition, it appears to me that a departure from a standard procedure is in fact a mistake and should be categorized as an Error. Further, my judgment appears to be consistent with the QA measures of Criterion 5 of Appendix B, which requires in part that activities affecting quality shall be prescribed by documented instructions, procedures, or drawings and shall be accomplished in accordance with these instructions, procedures, or drawings.

Q: Does each design error disclosed by the IDVP or NRC audits represent a multiple failure of the design control system?

A: Yes. Each error represents at least two failures; the original failure or error itself, and the accompanying failure in the QA program or its implementation which allowed the original failure to remain undetected. An undetected error may also represent a failure of more than two "gates" in the QA program. For example, an error may represent a failure by the originating design engineer, a failure by the verifying engineer to detect the error, a failure by the engineering assurance organization to detect the error in its surveillance activities, and a failure by the QA organization to detect the error during its audits. In the preceding, the term "gate" means a control measure in the design process at which a design attribute is checked or verified for conformance. Thus, the effect of the multiple gates is to provide several opportunities to detect a design nonconformance.

Q: Will a good QA program assure that design failures will be totally eliminated?

A: No. Rather, in designing any complex facility, errors by the originating engineer are inevitable because people are not infallible. QA programs recognize human imperfections and thus impose a management control system to detect these inevitable errors and, therefore, to ensure that the facility is, in fact, designed to the requisite licensing criteria.

Q: Will a good QA program detect all design discrepancies?

A: No. Clearly while the goal of a QA program for a nuclear plant is to assure zero defects, it is equally clear that some defects will escape detection. In my experience, the gates in the QA program for safety-related items for a nuclear plant are designed to assure that all critical errors (Classes A, B, and AB) will be detected. Further, it is expected that the vast majority of major errors (Class C) will be detected. A lesser detection rate is acceptable for minor design discrepancies. Such a systematic concept for classifying characteristics of error provides a rational basis for designing the gates in a QA program. Thus, design features with critical characteristics require special emphasis in the QA program. Correspondingly, such a system provides a reasonable basis for applying a lesser degree of QA controls to design features which might result in a minor error.

Q: Have you made any significant assumptions in preparing this testimony?

A: Yes. Based on my review of the Board's August 16, 1983 order, and my attendance at the pre-hearing conference on August 23 and 24, it is my understanding that the reopened Diablo Canyon design quality assurance proceeding will focus on whether the verification program (the IDVP and ITP) has demonstrated that the design of Diablo Canyon is now in compliance with the applicable NRC regulatory requirements and the PG&E licensing criteria. The licensing criteria (or commitments) are contained in the PSAR, FSAR, Hosgri Report, SER, SER Supplements, and other licensing documents including letters from PG&E to the NRC. Consequently, my testimony will not address the question of whether PG&E and its design subcontractors complied with the Commission's design quality assurance regulations and associated SAR commitments in the period prior to November 1, 1981. Rather, it is now assumed that the design QA process and its implementation prior to November 1, 1981, cannot be relied upon to assure the adequacy of design.

Q: Does the preceding assumption identify a fundamental question you will address in the testimony?

A: Yes. In my judgment the fundamental question regarding the Diablo Canyon design, which encompasses all the matters set forth in the contentions, has as its essence one basic question: Whether the IDVP and the ITP "after the fact" verification efforts provide an equivalent level of assurance regarding the design of Diablo Canyon as would have been obtained by a QA/QC program conducted in a timely fashion in compliance with the regulatory requirements of Appendix B.

IV. FAILURE TO ASSURE AS-BUILT PLANT CONFORMS TO TO DESIGN DOCUMENTS

Q: What contention addresses the verification program efforts to assure that the as-built plant conforms to the design documents?

A: Contention 5. This contention, as set forth in the Board's August 26, 1983 Order, reads as follows:

"The verification program has not verified that Diablo Canyon Units 1 and 2 'as built' conform to the design drawings and analyses."

Q: What was the initial concern regarding the matters encompassed by this contention?

A: All reviews of PG&E's design control practices for its design activities conducted prior to November 1, 1981 disclosed numerous examples where the as-built Diablo Canyon plant failed to conform to the design documents. This pattern of configuration control noncompliance was identified by PG&E in its review in response to NRC Bulletin 79-14. A similar pattern of differences between the as-built plant and design documents was disclosed by the IDVP in the Phase I reviews and by Brookhaven National Laboratory (BNL) in its independent analysis of the vertical response of the containment annulus structure.

Q: Did other reviewers of the pre-November, 1981 design activities determine that design and modification problems indicate the need for improved engineering support?

A: Yes. The Institute of Nuclear Power Operations (INPO) visited the Diablo Canyon site during the week of January 25, 1982. In its report dated February 12, 1982, INPO recommended changes to the design change control practices as follows:

"Improve the existing modification program to ensure that changes to the plant are controlled and performed in a timely manner. For example:

a. Complete revisions to affected documentation before modified systems are returned to service.

b. Issue final as-built documentation and update procedures as soon as possible.

c. Assign review and approval responsibilities for non-critical modifications to on-site technical support department engineers." (Governor's Exhibit ("Gov. Exh.") 11.)

Q: Did the DCP initiate changes in its design configuration control practices for the post-November 1981 design activities?

A: Yes. The engineering review of plant modifications resulting from IDVP identified errors has been performed in accordance with Engineering Manual Procedure 3.60N; PG&E Engineering Manual Procedure No. 3.7, Rev. 5; PG&E Engineering Manual Procedure No. 3.7, Rev. TR-9; Diablo Canyon Project Engineer's Instruction No. 13, Rev. 0; and Diablo Canyon Project Engineer's Instruction No. 13. These procedures require that Engineering review the result of construction activities which differ from the Design Change Notice (DCN).

Q: Did PG&E initiate other reviews of the as-built condition of the plant?

A: Yes. A description of the design and construction configuration control process as well as the proposed as-built walkdown activities by the DCP was provided to the NRC in a June 24, 1983, letter from Schuyler of PG&E to Eisenhut.

Q: Have the preceding corrective measures fully resolved the as-built configuration control problem?

A: No. The IDVP's recent review of the sample of design documents resulting from the DCP's corrective action program

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identified a number of instances where the as-built plant differed from the design documents.

Q: Were EOIs issued for these conditions?

A: Yes. The most significant EOIs resulting from the IDVP corrective action review are briefly summarized in Table 8-1 which is appended to the testimony. Configuration control errors identified by the IDVP included the following:

(a) Differences disclosed between "as analyzed" and "as-built" bolt sizes (EOIs 1120, 1121).

(b) Differences disclosed between "as-built" and "as-analyzed" instrument tubing support (EOI 1123).

(c) Design analysis finite element model of the control room slab used to generate Hosgri spectra not agreeing with the field verified location of the supporting wall (EOI 1124).

(d) Incorrect valve modeling in DCP seismic reanalyses (EOI 1133, 1135, 1137).

Q: Did the IDVP also identify other discrepancies which were not the subject to EOI's?

A: Yes, the IDVP review of the DCP corrective action measures, as summarized in the ITRs, identified a large number of configuration control discrepancies. The discrepancies disclosed in the ITRs are summarized in Table 5-1 which is appended to this testimony. For reasons not documented by the IDVP, the majority of the discrepancies documented in Table 5-1 were not the subject of EOIs. In my judgment, the failure of the IDVP to initiate EOIs for these matters is a serious omission. Further, the failure to systematically initiate EOIs appears to be contrary to the IDVP's procedures for identifying and evaluating potential errors.[2/]

Q: Can you provide examples of configuration control discrepancies identified by the IDVP which were not documented in EOIs?

A: Yes. Configuration control discrepancies between the as-built plant conditions and the design documents identified by the IDVP during its verification of post-November 1981 design activities are denoted with an asterisk in Table 5-1. Some examples of such configuration control discrepancies in design documents are the following:

(a) Pipe weight: A 2000 pound flow element (weight equivalent to a pipe length of about 2.7 times pipe diameter) was not included in the DCP model (ITR 59).

(b) Piping geometry: The DCP coded one portion of 20-inch diameter pipe 3 feet shorter and another portion of 12-inch diameter pipe 4 feet longer, than indicated by IDVP field verification (ITR 59).

(c) Support modeling: Support 55S/64R was modeled as a rigid + Y-directional support, whereas the IDVP field verification found it to be a gravity support (ITR 59).

(d) Valve Modeling: The weights for Valves LCV-113 and -115 were modeled 45% low for valve bodies and 8% low for valve operators. In addition, minor differences in the DCP eccentricity calculations were noted (ITR 59).

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2. The IDVP in its Phase II Program Plan stated that

"Open Item Reports are prepared for the purpose of reporting an IDVP response to a QA and Design Control Practices deficiency, a violation of the verfication criteria or an apparent inconsistency identified in the performance of the work."

(e) Support locations: A 3-foot difference in location of one of the supports was noted (ITR 59).

(f) Valve Modeling: The DCP analyzed Valve 8805B with the operator in the vertical position, but an IDVP field verification found this operator to be in the horizontal position. Also, differences were found for valve center of gravity locations for valves 8805A and 8805B and IDVP [sic] and for operator support locations (ITR 59).

(g) The IDVP field verification noted a weld across the top of a member attached to the process pipe. The DCP drawing did not show this weld (ITR 60).

(h) The IDVP field verification noted that one of the four restraints comprising support #98/83 was a small box frame bilateral rather than a tee-shoe and clamp assembly as shown on the DCP support drawing (ITR 60).

(i) Unintentional restraints, as shown on the DCP walkdown isometric and by IDVP field verification, were not explicitly addressed in the analysis (ITR 61).

(j) DCP sketches and as-built data did not correlate with the support analysis. In addition, DCNs for modifications were omitted from the documentation package (ITR 63).

(k) Two of the bolts in the four bolt plate joint between two column members had been cut out to prevent pipe movement interference. The impact of the reduced section was not evaluated (ITR 65).

Q: Based on the foregoing, what do you conclude?

A: The IDVP's reviews to date of a sample of the product (the design documents) relating from the QA/QC process for the DCP's corrective action measures demonstrate to me that configuration control deficiencies continue to exist at Diablo Canyon. Such configuration differences between the as-built plant and the design documents are, in my judgment, contrary to the design control and document control requirements of Criteria 3 and 6 of Appendix B. The configuration control deficiencies also indicate a failure to comply with the requirement of Criteria 10 and 11 that inspections and tests be conducted to verify conformance with drawings in that the proper conduct of such tests and inspections would not result in differences between the as-built plant and design documents remaining undetected. Finally, the continued existence of discrepancies between the "as-built" and "as-designed" configuration of the plant indicate that, contrary to Criterion 16 of Appendix B, the corrective actions by the DCP have not been adequate to assure that all conditions adverse to quality are identified and corrected, and that the cause of the discrepancy is determined and action taken to preclude repetition of similar discrepancies.

Q: What do you now recommend?

A: As a minimum, the verification program should take the following steps:

(a) Examine the numerous past and current examples of known discrepancies between physical configuration and design documents, determine the root causes for those discrepancies, and make all changes in design documents and physical installations required by that analysis.

(b) Once it is believed that all root causes have been identified and all resulting discrepancies located and corrected, the conclusion should be confirmed

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by examining a random sample of installations and verifying that they conform to the design documents.

(c) Modify the procedures for the design-construction configuration control interface to insure that all deviations from design documents made by construction are promptly examined, approved and documented by engineering in compliance with regulatory requirements.

V. <u>FAILURE TO REVERIFY WESTINGHOUSE DESIGN SERVICES</u>

Q: What contention addresses the verification program efforts to reverify the design services subcontracted by PG&E to Westinghouse?

A: Contention 6. This contention, as drafted by the Board in its August 26, 1983 Order, reads as follows:

> "The verification program failed to verify that the design of safety related equipment supplied to PG&E by Westinghouse met licensing criteria."

Q: To what extent did the ITP reverify the safety-related design activities performed by Westinghouse for Diablo Canyon?

A: The ITP, with assistance from Westinghouse, conducted a limited verification of the design of Westinghouse supplied equipment. The ITP review of Westinghouse was characterized by PG&E as follows:[3]

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3. PG&E's Answer to Governor Deukmejian's Third Set of Interrogatories, September 19, 1983, page 53.

INTERROGATORY NO. 51:

With respect to contention 6, do you deny that the verification program failed to verify that the design of safety related equipment supplied to PGandE by Westinghouse met licensing criteria?

RESPONSE TO INTERROGATORY NO. 51:

No. The seismic design of all safety related equipment furnished by Westinghouse was not reanalyzed. Whenever findings of the verification program altered the input to specific pieces of safety-related equipment, that equipment was requalified by Westinghouse and reviewed by the DCP.

Q: Was a similar interrogatory addressed to the IDVP?

A: Yes.

Q: What was its response?

A: The IDVP responded to Governor's interrogatory as follows:[4/]

ANSWER TO INTERROGATORY NO. 51

Since the IDVP did not review any verification that the ITP may have performed of the design of safety-related equipment supplied to PG&E by Westinghouse, the IDVP neither admits nor denies the portion of contention 6 that relates to any such activities by the ITP. With respect to activities by the IDVP, although the IDVP verified the Westinghouse-PG&E interfaces within the scope of the IDVP programs, it did not verify the design of safety-related equipment supplied to PG&E by Westinghouse."

Q: How would you characterize the extent to which the IDVP and the ITP reverified the safety-related design activities performed by Westinghouse for Diablo Canyon?

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4. IDVP's Answers to Governor George Deukmejian's Third Set of Interrogatories, September 21, 1983, page 48.

A: The preceding statements by PG&E and the IDVP indicate there is general agreement that neither the IDVP nor the ITP conducted a systematic verification of the design of Westinghouse-supplied safety-related Nuclear Steam Supply Equipment.[5/] In addition, the IDVP did not perform a verification of the Westinghouse design services summarized in Appendix A of ITR-9. Rather, the IDVP conducted only a limited review of the Westinghouse-PG&E design interface. For example, with respect to seismic design, when the IDVP examined the transmittal of Hosgri spectra it only verified on a sampling basis that the applicable spectra were actually used for equipment qualification. Similarly, the IDVP review of the non-seismic safety aspects of the Auxiliary Feedwater System design, as well as the Reedy Phase II QA audit, failed to involve anything more than an examination of the design interface between PG&E and Westinghouse.[6/]

Q: Did the limited IDVP review disclose potential design errors in the Westinghouse activities for Diablo Canyon?

A: Yes, there is evidence that design errors have remained undetected by the Westinghouse QA program. For example, the vertical spectra used by Westinghouse for qualifications of the accumulators is in error. For the vertical direction, Westinghouse used two-thirds of the tau <u>filtered</u> spectra, rather than two-thirds of the <u>unfiltered</u> spectra as committed

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5. Also, see IDVP Final Report, pages 4.1.4-3.

6. IDVP Final Report, Section 4.1.3 and ITR-11.

to at page 4-3 of the Hosgri Report. Further, in the BNL review of ITR-11, BNL reviewers noted that errors were disclosed in 30% of the Westinghouse samples examined by the IDVP. Therefore, BNL questioned, as I question, the adequacy of the IDVP's verification of Westinghouse seismic design activities as follows:[7]

> "Further, the large percentage of exceptions (30%), where Westinghouse qualification spectra did not completely envelope the Hosgri spectra, would warrant additional samples if a complete check of the spectra criteria was intended."

However, there is no evidence that TES implemented the BNL suggestion to conduct additional sampling.

Q: Was the IDVP review of Westinghouse design activities further limited?

A: Yes. For example, the verification of system design pressures and temperatures for safety-related systems, including its use in equipment specifications, resulting from a generic concern were not included in the IDVP's additional verification program for items within the Westinghouse design scope, but rather were limited by the IDVP to PG&E design scope systems.[8]

Q: Did the ITP's limited review also reveal design errors in the Westinghouse activities?

A: Yes. The seismic review of the main control boards (MCB) conducted by Westinghouse in response to new spectra for the

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7. Summary and Evaluation Report, ITR-11, TR-5511-2, Rev. 0, Brookhaven National Laboratory, November 2, 1982. (Gov. Exh. 12.)

8. SER Supplement 18, page C.4-25.

auxiliary building developed by the ITP identified an error in the original seismic qualification analysis. The MCB was procured by Westinghouse from Reliance, and Reliance used a private consultant to seismically qualify the MCB by analysis. The original analysis in the early 1970's predicted the lowest natural frequency of the MCB to be above 70 Hz based on the analytical model used. In the current evaluation process, the MCB was modeled using field measurements and results of in-situ tests. The in-situ tests pointed out the existence of natural frequencies between 15 to 28 Hz which is much below the 71 Hz calculated originally. Because of this error, and because of the severity of the current Hosgri spectra at the base of the MCB in the 15 to 33 Hz range, Westinghouse has provided modifications to the MCB.[9]

Q: Based on the foregoing, what do you now conclude?

A: It is evident that the conclusions resulting from the IDVP and ITP reviews on samples of other design service contractors cannot be extended to provide meaningful conclusions as to the adequacy of Westinghouse-supplied NSSS equipment or of the adequacy of Westinghouse design services. Further, Westinghouse was the responsible design organization for over 70% of the Diablo Canyon safety-related systems. As NSSS contractor, Westinghouse had responsibility to develop and implement the majority of the non-structural Diablo

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9. SER Supplement 18, Section 3.5.3. Also, see transcript of Westinghouse/PG&E/NRC meeting on May 20, 1983, regarding seismic qualification of the MCB.

Canyon safety features committed to by PG&E in the FSAR and other licensing commitments provided in response to the NRC regulations. In particular, Westinghouse supplied the Diablo Canyon designs provided to assure compliance with a significant number of the General Design Criteria set forth in Appendix A to 10 C.F.R. Part 50 of the NRC regulations.

Q. What do you recommend?

A. What is needed is a systematic verification of Westinghouse design activities. The verification should include a suitable sample of Westinghouse design documents and activities sufficient to assure that <u>all</u> Diablo Canyon licensing criteria are met, to assure the efficacy of the Westinghouse QA process, and to assure that all basic causes and generic implications of any errors detected have been thoroughly assessed.

VI. FAILURE TO IDENTIFY ROOT CAUSES

Q: What contention addresses the verification program efforts to identify the root causes of the design errors detected by the verification program?

A: Contention 7. This contention, as set forth by the Board's Order, reads as follows:

> "The verification program failed to identify the root causes for the failures in the PG&E design quality assurance program and failed to determine if such failures raise generic concerns."

Q: How do you define "root cause"?

A: "Root cause" is defined as the underlying basis that precedes and usually induces an effect or result.

Q: Does the term "root cause" mean the same as "basic cause" as used by the IDVP?

A: Yes. The IDVP in Section 6.3 of its Final Report defined basic cause as "the underlying problem or concern which led to or provided the basis for an identifiable error of commission or omission," which is equivalent to the preceding definition of root cause.

Q: What does the term "generic concern" mean?

A: "Generic concern" refers to the potential of each error to exist in a similar manner in other, unreviewed parts of the plant. Thus, the corrective action verification for a potential generic concern should be conducted to the depth and extent required to ascertain whether the specific error is one of a number of similar errors in other, unreviewed items of the Diablo Canyon plant.

Q: Were generic concerns identified by the IDVP?

A: Yes. Generic concerns were purportedly identified by the IDVP "where one or more specific errors had been identified or because the IDVP believed that a generic concern could exist even though a specific concern was satisfactorily resolved."[10/] Thus, the term generic concern, when used by IDVP, is intended to indicate that the error (Class A or B) is "potentially applicable to structures, systems, or

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10. IDVP Final Report, Section 3.5.5, page 3.5-4.

components in addition to that for which it was first identified.[11/]

Q: Was an assessment of the basic cause of the identified errors required of the IDVP?

A: Yes. The Commission Order and the November 19, 1981 Staff Letter both require that the IDVP conduct an assessment of the basic cause of all the design errors identified by the IDVP. The Staff and the Commission required that the IDVP provide the following three part assessment for each identified design error:

> "A technical report that fully assesses the basic cause of all design errors identified by this program, the significance of design errors found, and their impact on plant design." See Commission Order, Attachment 1, at part 1(a)(5)(b) and Staff Letter at parts 1(b), 2(b), and 3(b).

Q: Where is the IDVP assessment documented?

A: The IDVP Final Report in Section 6.0 contains its evaluation with the basic cause of design errors documented in a very general manner in Section 6.3. The significance is set forth in Section 6.4, while the impact is briefly discussed in Section 6.5.

Q: Did the ITP also provide a general statement describing its determination of the basic causes of the identified errors?

A: Yes. The ITP documentation of basic causes is provided in Section 1.8 of the Phase I Final Report and Section 3.0 of the Phase II Final Report. In no case, however, did the ITP,

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11. IDVP Final Report, Section 5.1, page 5.1-2.

or the IDVP, correlate the basic causes cited to the identified errors.

Q: Should the IDVP and ITP have made such a correlation?

A: Yes. The IDVP's and the ITP's failure to make this correlation is contrary to the corrective action requirements of Criterion 16 of Appendix B.[12/]

Q: Why is this so?

A: Criterion 16 requires that a QA audit ascertain the causes of QA program failings so that an appropriate corrective action program can be devised. Part of any proper corrective action program is a determination as to whether the observed failure has generic implications. Fundamental to any investigation of the generic implication of any QA failure is a determination of the root cause of that failure. It is only when the root cause of a failure is identified that the question of its generic implications can be addressed. Instead of analyzing the root cause of each design error it uncovered as a mechanism toward assessing the generic implications of that error, the IDVP and the ITP provided no more than global conclusions regarding basic cause with no specific reference to any of the identified errors. Further, the global basic causes identified by the IDVP and the ITP primarily relate to the seismic errors. Thus, the multiple failures (basic causes) which resulted in the non-seismic

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12. The failure to develop the correlation is also contrary to the requirements for the assessment of basic causes set forth in the Commission Order and the Staff's November 19, 1981, Letter.

design errors were not systematically addressed. This is a serious omission.

Q: What do you mean by multiple basic causes?

A: In general each error identified by the IDVP was the result of multiple causes. For example, as discussed in Part III of this testimony, each design error detected by the IDVP or ITP represents at least two failures: the failure itself, and the accompanying failure or failures in the QA gating program or its implementation which allowed the original failure to remain undetected. Thus, an adequate evaluation of the basic cause must address the cause underlying each failure.

Q. Did the ITP or IDVP assess the potential generic concern which can result due to the failure to establish or implement the QA/QC measures required by Appendix B?

A. No. This is a serious deficiency in the verification program's assessment of basic causes.

Q: Is it possible to go back in time to ascertain the cause of a design error?

A: Yes. Indeed, Criterion 16 of Appendix B requires that the causes of conditions adverse to quality be identified and corrected.

Q: Can you provide an example of how to conduct the two part assessment of basic causes for a particular error?

A: Yes. The original mirror image design error provides such an example. The error was that the diagram used to locate Vertical Seismic Floor Response (VSFR) for the Unit 1 containment annulus was applicable to Unit 2 but was identified as being that of Unit 1. Since the units are opposite hand, this resulted in an incorrect orientation of VSFR spectra for Unit 1 component and system design. The origin of the error was in the PG&E submittal to its principal seismic design subcontractor, John A. Blume and Associates (Blume), of an unverified, unlabeled, handwritten sketch of the Unit 2 opposite hand geometry in place of the Unit 1 geometry.[13/] Blume personnel further compounded the "sketch" error by one of their own. Blume assumed that the layout of the annulus areas of Units 1 and 2 were identical when, in fact, they were mirror images.[14/] In my judgment the underlying cause of the initial failure was the breakdown of design interface control in that unverified and uncontrolled design data were provided to Blume contrary to Criteria 3, 4, and 5 of Appendix B regarding design control, procurement document control, and procedural control.

The initial failure was not detected because the design control and document control measure failed to assure, as required by Criteria 3 and 6, that documents were reviewed for adequacy and approved for release by authorized personnel and were distributed to and used at the location where the prescribed activity was performed. In addition, Blume was not contractually obligated by PG&E to a QA program until

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13. LER 81-002/01T-0, October 12, 1981. (Gov. Exh. 13.)

14. NRC Inspection Report 50-275/81-29, page 2. (Gov. Exh. 14.)

1978, eight years after Appendix B was adopted and twelve years after Blume's first engineering services on Diablo Canyon, contrary to the requirements of <u>Criterion 2</u> that a QA program be established "at the earliest practicable time." Also, PG&E's qualification and evaluation of service contractors as required by <u>Criterion 7</u> did not occur until after completion of the subject engineering. Finally, audits of suppliers, such as Blume, were not carried out in a timely fashion to verify compliance with the QA program requirements and to determine the effectiveness of the program as required by <u>Criterion 18</u>. Thus, the appropriate corrective action measures as set forth in <u>Criterion 16</u> were not initiated by PG&E or its subcontractor.

Q: Did the IDVP or ITP conduct such a two part evaluation as you have suggested?

A: No. In no design error did the IDVP or ITP specifically identify and document the second failure or failures in the quality assurance program or its implementation which allowed the initial failure to remain undetected. Further, in most cases, neither the IDVP nor the ITP provided documentation identifying the underlying cause, or series of causes, leading to the initial failure.

Q: Do you have any examples to illustrate the weaknesses you described in the IDVP and ITP treatment of basic cause?

A: Yes. The resolutions of EOI's No. 7002, 8010, 8017, 8022, 8023, and 8060 all demonstrate a failure to completely address the basic causes of the identified errors.

Q: How does the resolution of EOI 7002 exemplify a failure to address the basic cause?

A: EOI 7002 resulted from an R. F. Reedy finding that no objective evidence was available to demonstrate that the effects of jet impingement on components inside containment had been considered.[15] In order to resolve EOI 7002, the DCP developed the analysis of jet impingement inside containment as committed to in FSAR Section 3.6, paragraph 3.6.[16]

The above resolution, while it may address the specific error which led to the establishment of EOI File No. 7002, does not address the question of why no documentation of the jet impingement review was available when the FSAR stated that a review had been performed.

PG&E, in its Final Report on Phase II of the ITP, discussed the cause of EOI 7002 as follows:[17]

> As was typical for plants of this vintage, formalized analyses for jet impingement were not done for the original plant design, which was based on inherent separation of safety systems through an appropriate arrangement of equipment, piping, walls, and other structures. The current NRC guidelines for formal jet impingement evaluation defined in Section 3.6 of the Standard Review Plans had not been issued at that time. Jet impingement effects were, however, taken into account. The plant arrangement was designed so that a

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15. Potential Program Resolution Report, File No. 7002, revision 0, IDVP, October 11, 1982. (Gov. Exh. 15.)

16. Open Item Report, File No. 7002, revision 5, IDVP, July 26, 1983. (Gov. Exh. 16.)

17. "Phase II Final Report, Design Verification Program", Pacific Gas & Electric Company, June 1983, pages 3-17.

catastrophic break of a high-energy line or other unexpected phenomenon would not affect a redundant safety system, and the original design included appropriate consideration of break locations and calculations for jet impingement forces on major structures.

As nuclear plant design progressed and requirements became more formalized and were upgraded, more rigorous documentation of the adequacy of jet impingement design was required by the NRC. The DCP has upgraded the original design basis by the performance of a formalized, rigorous investigation of jet impingement utilizing the current requirements and techniques."

One can readily understand that when Diablo Canyon was first designed, there was no requirement for a formal and rigorous jet impingement analysis. However, between the original design of Diablo Canyon and October 11, 1982 (when the R. F. Reedy finding was dated), PG&E made a commitment in their FSAR that the effects of jet impingement inside containment would be addressed. Therefore, the PG&E explanation does not identify the the reason why PG&E's QA program did not identify this failure to perform the jet impingement analysis earlier?

Q: How does the resolution of EOI 8010 exemplify a failure to address the basic cause?

A: EOI 8010 resulted from an IDVP concern that low pressure piping and components would be overpressurized by a variety of operational occurrences.[18] In order to resolve EOI 8010,

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18. Open Item Report, File No. 8010, revision 0, IDVP, September 13, 1982. (Gov. Exh. 17.)

PG&E implemented modifications to assure the protection of low pressure components.[19] Further, to resolve the generic implications raised by EOI's 8009, 8010 and 8062, the DCP provided additional verification of the selection of design temperature, pressure, and differential pressure across power operated valves.

The IDVP reviewed part of the DCP reanalysis and reported its findings in ITR 46. On page 2-2 of ITR 46, the IDVP stated, "concerns similar to those originally found in the pressure/temperature review of the AFW system were found by PG&E also to exist in the Main Steam System and portions of the Component Cooling Water System." However, the IDVP documentation of the resolution of EOI 8010 and of the additional verification of design temperature/pressure does not identify the reason behind the original error, or the subsequently-identified errors in other systems.

PG&E, in its Final Report on Phase II of the ITP, discussed the cause of EOI 8010 as follows:[20]

> "...EOI 8010 arose as a result of a later system modification to improve start-up flow to the coolers. In implementing the flow improvement, the designers failed to recognize the small increase in pressure resulting from the design change."

While the above explanation does identify a reason why the error (EOI 8010) occurred, it raises further questions

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19. Error Report, File No. 8010, revision 8, IDVP, March 4, 1983 (Gov. Exh. 18); Program Resolution Report, File No. 8010, revision 11, IDVP, June 1, 1983 (Gov. Exh. 19).

20. Ibid. 17, pages 3-12.

which should be answered before the basic cause may be considered to have been addressed. For instance, does a procedure exist which requires the designer to evaluate possible pressure changes whenever a modification is made to a fluid system? Also, what caused the additional errors which were reported in ITR 46 but given no EOI designation?

For the above reasons, the resolution of EOI 8010 does not address the basic cause leading to the specific error, nor does it identify the QA error which allowed the original error to remain undetected.

Q: How does the resolution of EOI 8017 exemplify a failure to address the basic cause?

A: EOI 8017 resulted from an IDVP concern that separation criteria were violated by an electrical control transfer switch where control power from two redundant safety-related sources was brought together.[21] In order to resolve the specific concern of EOI 8017, the DCP modified the transfer switch to provide separation of the power sources.[22] Further, in order to resolve the generic implications of EOIs 8017 and 8057, the DCP provided additional verification of electrical separation which the IDVP reviewed and reported in ITR 49. On page 2-1 of ITR 49, the IDVP states, "The PG&E review resulted in the identification of separation and

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21. Open Item Report, File No. 8017, revision 0, IDVP, October 4, 1982. (Gov. Exh. 20.)

22. Ibid. 17, pages 3-19.

single failure concerns similar to those addressed in the initial sample."

The IDVP documentation did not address the reason for the original error, or the QA error which allowed the original error to remain undetected. PG&E, in their Final Report on Phase II of the ITP, discussed the cause of EOI 8017 as follows:[23/]

> "In the early design of the plant, it was not intended that the separation criteria be literally applied all the way to the redundant devices and terminal blocks where the circuits came together within panels. Within that context, it was a standard practice to weigh competing considerations for low probability failure events. The value of operational flexibility gained by cross-tying redundant trains, for example, would be weighed against the unlikely occurrence of failure at the point of the cross-tie. Often the gain in operational flexibility outweighs the risk of the local failure at the point of cross-tie."

As in the case of EOI 7002, it is readily understood that certain requirements were not effective at the time of time of Diablo Canyon's initial design. However, the error which led to the establishment of EOI file 8017, and the errors which were identified in the DCP's additional review of separation represent violations of separation criteria which were committed to in the FSAR. PG&E's explanation does not address the question of how these errors occurred or how they remained undetected by the PG&E QA program.

Q: How does the resolution of EOI 8022 exemplify a failure to address the basic cause?

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23. Ibid. 17, pages 3-20 and 3-21.

A. EOI 8022 resulted from an IDVP concern that certain circuit breakers in the 4160V safety-related electrical distribution system had interrupting ratings less than the short circuit interrupting currents in certain operating conditions.[24] In order to resolve EOI 8022, the DCP obtained a letter from GE documenting the actual short circuit interrupting capacities of the circuit breakers as significantly higher than the rated capacity, and also higher than the calculated duties.[25]

Although the GE letter may have resolved the specific concern of the under-capacity of circuit breakers, neither the IDVP nor the DCP documentation has addressed the question of how the design error originally came about, and why the error was not detected by the PG&E QA program.

Q: How does the resolution of EOI 8023 exemplify a failure to address the basic cause?

A: EOI 8023 resulted from an IDVP concern that, under certain accident conditions, the voltages on the Engineering Safeguards 480V system buses may be insufficient for continuous operation.[26] In order to resolve EOI 8023, PG&E

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24. Open Item Report, File No. 8022, revision 0, IDVP, October 12, 1982. (Gov. Exh. 21.)

25. Error Report, File No. 8022, revision 5, IDVP, March 10, 1983; Interim Technical Report 24, revision 1, IDVP, May 4, 1983. (Gov. Exh. 22.)

26. Open Item Report, File No. 8023, revision 0, IDVP, October 12, 1982. (Gov. Exh. 23.)

adjusted the transformer tap settings on the 230 kV start-up transformers and on Buses 1F, 1G, and 1H.[27]

The IDVP documentation does not address the question of why the potential for undervoltage existed in the design, nor why the condition was not detected by PG&E's QA program. The basic cause of EOI 8023 is not discussed in PG&E's Final Report on Phase II of the ITP. Thus, neither the IDVP nor PG&E have addressed the basic cause of EOI 8023.

Q: How does the resolution of EOI 8060 exemplify a failure to address the basic cause?

A: EOI 8060 resulted from an IDVP concern that an interaction involving the runout control system could limit Auxiliary Feedwater (AFW) flow to less than minimum values in certain operating conditions.[28] In order to resolve EOI 8060, PG&E calculated new runout control system setpoints and implemented the changes in the field.[29]

The IDVP documentation does not address the question of why the design included the potential for adverse interaction between the runout control system and AFW flow, nor does it identify the QA error which allowed the design error to remain undetected. The basic cause of EOI 8060 is not

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27. Program Resolution Report, File No. 8023, revision 5, IDVP, March 11, 1983. (Gov. Exh. 24.)

28. Open Item Report, File No. 8060, revision 0, IDVP, October 29, 1982. (Gov. Exh. 25.)

29. Error Report, File No. 8060, revision 5, IDVP, March 15, 1983. (Gov. Exh. 26.)

discussed in PG&E's Final Report on Phase II of the ITP. Therefore, neither the IDVP nor PG&E has addressed the basic cause of EOI 8060.

Q: Are the preceding six EOI resolutions the only examples of failures by the IDVP and ITP to address the basic causes of design errors?

A: No, they are only indicative of the methodology used by the verification program to identify basic causes for errors. Further examples have not been presented in my testimony in the interest of brevity.

Q: In summary, what is your conclusion regarding Contention 7?

A: The corrective action measures initiated by the ITP in response to the design errors identified by the IDVP do not in a number of cases fully respond to the root cause. Therefore, potential generic concerns were not raised, or were only partially addressed by the verification program.

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VII. INADEQUACIES IN THE ITP QA MEASURES INCLUDING ITS CORRECTIVE ACTION PROGRAM

Q: What contention addresses the adequacy of the ITP's quality assurance measures applied to the design modifications developed since November 1, 1981 as well as the sufficiency of the ITP's Corrective Action Program?

A: Contention 8. This contention, as set forth by the Board, reads as follows:

> The ITP failed to develop and implement in a timely manner a design quality assurance program in accordance with 10 CFR Part 50, Appendix B to assure the quality of the recent design modifications to the Diablo Canyon facility and the IDVP failed to ensure that the corrective and preventative action programs implemented by the ITP are sufficient to assure that the Diablo Canyon facilities will meet licensing criteria.

Q: What sources of information measure the adequacy of the ITP's quality assurance program including the Corrective Action Program activities?

A: There are three measures of the post-November 1, 1981 QA program and its implementation: design product verifications; design process audits; and regulatory compliance reviews.

Q: What do you mean by design product verification?

A: A design product verification provides a comparison of the Diablo Canyon design documents with the applicable design criteria. Such a review constituted the major focus of the IDVP's verification efforts. The IDVP corrective action review addressed a sample of the seismic and non-seismic safety-related design activities conducted since November 1, 1981. The design product verification is also very important since it provides a direct measure of the adequacy of the as-released for construction design documents.

Q: What were the results of the IDVP review?

A: The errors identified in the IDVP's design product review of design modifications since November 1, 1981 are summarized in Table 8-1 which is appended to this testimony. As set forth in Table 8-1, the review to date has identified approximately five (5) errors of Classes A and B, twelve (12) Class C errors, and one (1) so-called deviation.

Q: Did the IDVP in its review of the ITP Corrective Action Program also identify other discrepancies which were not the subject of EOIs?

A: A design product verification provides a comparison of the Diablo Canyon design documents with the applicable design criteria. Such a review constituted the major focus of the IDVP's verification efforts. The IDVP corrective action review addressed a sample of the seismic and non-seismic safety-related design activities conducted since November 1, 1981. The design product verification is also very important since it provides a direct measure of the adequacy of the as-released for construction design documents.

Q: What were the results of the IDVP review?

A: The errors identified in the IDVP's design product review of design modifications since November 1, 1981 are summarized in Table 8-1 which is appended to this testimony. As set forth in Table 8-1, the review to date has identified approximately

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five (5) errors of Classes A and B, twelve (12) Class C errors, and one (1) so-called deviation.

Q: Did the IDVP in its review of the ITP Corrective Action Program also identify other discrepancies which were not the subject of EOIs?

A: Yes, as previously discussed in Part IV of this testimony, the IDVP's corrective action review identified numerous design discrepancies which could have, but did not result in the issuance of an EOI. A list of such discrepancies is provided in Table 5-1 which is appended to this testimony.

Q: Should the IDVP have issued EOIs for the discrepancies tabulated in Table 5-1?

A: Yes. In my judgment, the discrepancies in general met at least one of the IDVP's criteria for issuing an EOI in that they represented:

(a) A deficiency in a QA and Design Control Practice;

(b) A violation of the verification criteria; or

(c) An apparent inconsistency identified in the performance of the work.

Q: What is the significance of the IDVP's failure to issue EOIs for identified discrepancies?

A: The EOIs identified by the IDVP in its review of the DCP Corrective Action Program understate the nature and extent of the discrepancies actually d[illegible] by the IDVP.

A: Can you provide an example of how this understatement is reflected in the IDVP's Final Report?

A: In its Final Report, the IDVP concluded that "only one additional analysis was found to use an improper value (stress intensification factor), as reported in EOI 1138"?[30/] Contrary to the IDVP's conclusion, Table 5-1 of this testimony sets forth over 10 examples drawn from ITR 59 where improper values of stress intensification factors (SIFs) were disclosed in the IDVP's verification of the ITP's post-November 1981 design activities. Moreover, further examples of misapplied SIFs, as document in ITR 60, are also presented in Table 5-1.

Q: What do you mean by design process audits?

A: A design process audit provides information concerning whether the DCP effectively implemented its quality assurance program.

Q: What are the key documents which constitute the DCP design quality assurance program?

A: The following documents form the DCP design quality assurance program and implementing procedures:

(a) The Bechtel Topical Report BQ-TOP-1, Rev. 3A, October 1980 (Gov. Exh. 27), describes the quality assurance program to be implemented by the DCP. Additional information and clarification of the program was provided to the NRC in a letter dated August 13, 1982, which modified the scope of the DCP QA Program;

(b) The Bechtel Nuclear Quality Assurance Manual (NQAM) (Gov. Exh. 28), as amended to correctly identify the Diablo Canyon Project quality assurance policies;

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30. IDVP Final Report, Section 5.6, page 5.6-2.

(c) The Bechtel Quality Assurance Department Procedures Manual (QADP) (Gov. Exh. 29) as amended for DCP provides procedures for Quality Assurance Department personnel utilized on the project;

(d) The PG&E Engineering Department Engineering Manual (Gov. Exh. 30) establishes the controls and procedures to be used by the DCP for design activities;

(e) The Diablo Canyon Project Engineering Instructions (PEI) (Gov. Exh. 31) provide supplemental instruction for the application of the Engineering Manual to the Diablo Canyon Project.

Q: Was a design process audit of the DCP quality assurance program conducted by the IDVP?

A: Yes, the results of a series of design control audits conducted by Reedy between November 11, 1982 and December 7, 1982 are set forth in ITR 41. In addition, Reedy performed a follow-up audit on March 17, 1983.

Q: What were the results of Reedy's design process audit?

A: The IDVP audit basically took a snapshot of the DCP design QA program at one point in time. In its limited review, the IDVP design control audit disclosed 24 deficiencies in the DCP quality assurance program development and implementation including incomplete records documentation, lack of procedures, procedures not being followed, inadequate training, failure to implement commitments in a timely manner, inadequate document control, deviations in design control activities, and failure to control procurement activities. However, these conditions were determined by the IDVP "to be due to incomplete documentation, because this audit was performed in the early stages of the DCP QA Program implementation."[31] While it is true that the DCP QA program was only established on August 20, 1982, it should also be remembered that the Reedy audit took place nearly one year after the issuance of the Order suspending the Diablo Canyon license. Thus, in my judgment one would have expected more progress in QA program implementation.

Q: Do you agree that none of the audit results identified by Reedy could have either a potential or real impact on the quality of design activities?

A: No. The Diablo Canyon QA/QC measures presumably were drawn up such that (a) the QA/QC measures were designed to achieve a necessary objective; and (b) if implemented properly, the QA/QC measures would have achieved the objective. In fact, however, the necessary implementation was not achieved. Instead, over a number of years, there were recurring observations of lack of necessary QA/QC attention.

The failure to implement the design control measures represents a serious concern primarily because it reflects a lack of discipline in and management attention to the QA/QC program. The QA/QC management program requires specified standards be reliably and repeatedly achieved, and that program objective was not obtained. In QA/QC, such lack of

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31. ITR 41, page 2.

attention to prescribed measures cannot be tolerated. Each QA/QC measure, once issued by responsible management, must be assumed to be important. The fact that the IDVP now in hindsight apparently finds the instances of non-compliance to be acceptable (or at least not a significant concern) represents a lack of attention to the necessary discipline and detail which constitutes a basic ingredient of a successful QA/QC program. Further, Mr. Reedy acknowledged during his deposition that he had not reviewed the recent EOI's 1120 to 1144 resulting from the IDVP's review of corrective action in order to determine the significance of the errors in terms of the QA program.[32] In my opinion, this is a significant omission in Mr. Reedy's review.

Q: Were other design process audits of the DCP quality assurance program conducted?

A: Yes. Both Region V of the NRC in its routine inspections and the DCP in its audit program evaluated the implementation of the design process. Similar to Mr. Reedy, Mr. Morrill of Region V acknowledged at his deposition that he had not evaluated the QA/QC significance of EOIs 1120 to 1144 in forming his opinion on the adequacy of the DCP QA program implementation.[33] Further, in spite of the past history of design process discrepancies at Diablo Canyon, Region V

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32. Deposition of Roger F. Reedy, September 22, 1983, pages 41, 42, 64, 65.

33. Deposition of Philip John Morrill, September 28, 1983, page 99. In addition, SER Supplement 18 does not address the potential QA/QC significance of these EOIs.

personnel did not significantly increase their design inspection activities at the DCP home offices during the past two years. Rather, in my judgment, a business-as-usual approach generally prevailed for design inspections.

Q: What do you mean by regulatory compliance review?

A: A regulatory compliance review provides an assessment of the quality program measures as compared to the regulatory requirements of Appendix B.

Q: Did the IDVP conduct a regulatory compliance review?

A: No. Rather, the IDVP relied upon the NRC's review of the DCP QA program as assuring that the program adequately addresses the requirements of Appendix B.

Q: Based on your assessment of the foregoing three measures, what is your conclusion?

A: The results of the IDVP design product verification, as well as its design process audits demonstrate that the ITP failed to satisfactorily execute a design quality assurance program for the design modifications developed since November 1, 1981. The results further indicate that, contrary to the requirements of <u>Criteria 1 and 2</u> of Appendix B, the DCP failed to establish and execute a design quality assurance program. Further, contrary to <u>Criterion 3</u>, the DCP's design control measures failed to assure that the Diablo Canyon design criteria were correctly translated into design documents. Indeed, the errors and potential errors set forth in Tables 5-1 and 8-1 demonstrate that the DCP QA program failed to adequately implement the required audits and corrective action measures contrary to Criteria 18 and 16 of Appendix B. This conclusion inevitably follows as a result of the identified errors since Criterion 18 requires that PG&E and its design contractors perform planned and scheduled audits to verify compliance with all aspects of the quality assurance program and to determine its effectiveness. Follow-up action is intended to be initiated to address the identified discrepancies. Guidance for such follow-up action is provided by Criterion 16 which requires that appropriate corrective action be initiated to correct the identified and any similar discrepancy, to determine the cause of the discrepancy, and to preclude recurrence of further similar discrepancies.

Q: What do you recommend?

A: Given the demonstrated number and nature of the errors disclosed in the IDVP's review of a sample of the Corrective Action Program, in my judgment it is reasonable to conclude that further critical errors (Class A or B) exist in the design of the plant which can only be uncovered by a rigorous and thorough verification program. Further, the cumulative impact of the major errors (Class C) when coupled with the critical errors indicate the necessity for further verification of the post-November 1, 1981 design activities.

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VIII. CONCLUSIONS

Q: Based on the foregoing, what have you concluded?

A: The IDVP and the ITP have detected and corrected a number of critical errors in both the Diablo Canyon design product, and the quality assurance program measures provided to control the design process. However, in my judgment the verification program has not yet demonstrated that the design of Diablo Canyon is now in compliance with all the applicable NRC regulatory requirements and all the PG&E licensing criteria in that:

(a) The verification program failed to verify a suitable sample of safety-related design activities for the design services subcontracted to Westinghouse by PG&E.

(b) The verification program failed to systematically identify the basic causes for either the initial failure or the failure of the PG&E design quality assurance process which allowed the errors disclosed by the IDVP and ITP to occur and remain undetected. As a result, potential generic concerns were not raised, or were only partially addressed by the verification program.

(c) The IDVP's field verifications of a sample of the design documents resulting from the ITP's Corrective Action Program demonstrated that all configuration control errors have not been detected and corrected. Rather, the continued existence of discrepancies between the "as-built" and "as-designed" configuration of the plant indicate that the corrective action measures initiated by the DCP have not been adequate to ensure that all conditions adverse to quality have been detected and corrected, and that the cause of such discrepancies is determined and action taken to preclude repetition of similar discrepancies.

(d) The results of IDVP's review of a sample of the post-November 1981 design activities conducted by the ITP's Corrective Action Program establish that the DCP failed to satisfactorily execute a design quality assurance program for its activities. Given the demonstrated number and nature of the design errors identified in the IDVP's review of the Corrective Action Program, in my judgment it is reasonable to conclude that further critical errors exist in the design of Diablo Canyon.

For the preceding reasons, the IDVP and ITP design verification efforts conducted to date have, in my judgment, failed to provide an equivalent level of assurance regarding the design of Diablo Canyon as would have been obtained by a QA/OC program executed in a timely fashion in compliance with the regulatory requirements of Appendix B.

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TABLE 5-1

TABLE 5-1

DISCREPANCIES IDENTIFIED IN CORRECTIVE ACTION REVIEW

DCP Analysis	Condition Noted by IDVP	EOI Issued
A. ITR #49 (Rev. 0)		
---	The PG&E review resulted in the identification of separation and single failure concerns similar to those addressed in the initial sample. Modifications were subsequently made to provide consistency with FSAR separation commitments.	No
B. ITR #54 (Rev. 1)		
---	In the verification of "as-built" conditions, the IDVP found two minor instances where the as-built condition did not match the design drawings. The first case concerned the clearance of the crane wheels and guide struts versus the crane rail. Plates were modified to allow the proper clearance, and these modifications had no impact on the structural integrity. Secondly, a nonstructural plate was welded to the outer box instead of the inner box of the guide strut. This discrepancy will be resolved by the DCP for the final resolution of the operational capability of the polar crane.	No *
C. ITR #55 (Rev 1)		
Calc 52.15.6.1.0	The DCP used a ZPA of 1.6g for the control room slab. The revised analysis of the control room slab showed various nodes with a maximum ZPA of 2.0g.	No
----	In certain cases, the DCP considered openings which were only temporary blockouts, or neglected a minor penetration opening in a wall.	No *

* The condition reflects a discrepancy between as-built conditions and the design documents.

DCP Analysis	Condition Noted by IDVP	EOI Issued
D. ITR #59 (Rev. 1)		
4-100, rev. 0	1. Valve modeling: The DCP neglected the weight of flange bolts which accounted for 7% of the total valve weight.	No *
	2. Stress computation: The DCP used a preliminary design pressure which was 240 psi (59%) below the value given in the subsequent DCP DCM.	No
	3. Piping geometry: A difference of 1.42 feet was noted for the length of a pipe segment.	No *
9-108, rev. 0	1. SIF applications: The DCP used 1.0 for a taper transition at the heat exchanger nozzle. The IDVP calculated the SIF to be 1.9.	Yes
	2. Interference: The DCP did not address the interference between the regenerative heat exchanger and the pipe (including interference due to insulation).	No
1-119, rev. 0	Pipe weight: A 2000 pound flow element (weight equivalent to a pipe length of about 2.7 times pipe diameter) was not included in the DCP model.	No *
2-111, rev. 0	1. Loading inputs: The DCP applied auxiliary building SAM displacements at Support 11-93SL. This support was field verified by the IDVP to be attached to the containment exterior building. Pressure effects, and thermal anchor motions at two supports were not considered in the DCP analysis.	No
	2. Piping geometry: The IDVP found that in the DCP analysis the location of Support 11-93SL differed from the as-built condition by 3 feet 2-3/16 inches.	No *

D. ITR #59(Rev. 1) (Contd)

DCP Analysis	Condition Noted by IDVP	EOI Issued
	The straight pipe between the elbow at nodes 15 and 23 was analyzed 4 feet 3 inches shorter than the dimension field verified by the IDVP.	
9-110, rev. 0	1. Piping geometry: A 3-foot difference was noted for elevation of Support 10-17SL between information provided by the support drawing and that used in the DCP analysis. A 1-foot difference between IDVP field information and DCP input for one pipe segment was also noted.	No *
	2. Mass point spacing: A mass point between two horizontal supports was not modeled in the DCP analysis.	No
	3. Loading inputs: Two thermal load cases were not considered by the DCP.	No
4-102, rev. 1	Piping geometry: The DCP coded one portion of 20-inch diameter pipe 3 feet shorter and another portion of 12-inch diameter pipe 4 feet longer, than indicated by IDVP field verification.	No *
4A-100, rev. 0	1. Valve modeling: The DCP neglected the weight of the flanges attached to Relief Valve RV-52. This resulted in a 9% difference in the total valve weight.	No *

DCP Analysis	Condition Noted by IDVP	EOI Issued
D. ITR #59(Rev. 1) (Contd)		
	2. SIF application: An SIF of 1.8 was not applied at a butt weld on straight pipe near Support 57N/72R. A SIF of 2.1 was also not applied for the socket weld at a socket.	No
	3. Loading inputs: DCP pressure and temperature inputs (based on preliminary design data) were up to 59% lower than values provided in the subsequent DCM.	No
	4. Interference: Pipe deflection at Support 57N/61R (Y restraint) exceeded support clearance in the Z direction.	No
8-106, rev. 1	1. SIF application: An SIF of 1.0 was applied at the pipe flued head interface, where an SIF of 1.9 was appropriate for a taper transition joint. SIFs of 2.1 were not specified for all applicable socket welding locations.	No
	2. Interference: The DCP did not address the unintentional restraint found by the IDVP on the vertical portion of the 3/4 inch vent line.	No *
4-113, rev. 0	1. Support modeling: Support 55S/64R was modeled as a rigid ± Y-directional support, whereas the IDVP field verification found it to be a gravity support.	No *
	2. Valve qualification: The gravity effect (1g) was not included in the acceleration qualification for Valve FCV-356, which has a horizontally mounted valve stem.	No

DCP Analysis	Condition Noted by IDVP	EOI Issued
D. ITR #59(Rev. 1) (Contd)		
4-113, rev. 0	3. SIF applications: SIFs applied at a 20-inch X 2-inch connection, and at a butt weld on straight pipe were up to 50% lower than SIFs calculated by the IDVP.	No
	4. Loading inputs: The design pressure (preliminary) in one of the lines was 57% lower than the subsequent DCM value.	No
2-105, rev. 0	1. SIF applications: The DCP applied an SIF of 1.0 for three branch connections. The required SIFs were determined by the IDVP to be 1.628, and 1.07. The DCP did not apply a taper transition SIF (1.9 maximum) to a flange/pipe interface. SIFs for butt welds on straight pipe were also not considered by the DCP.	No
	2. Loading inputs: The DCP vertical Hosgri spectra (based on preliminary data) was found to be lower than that determined alternately by the IDVP using subsequent DCM values.	No
2-120, rev. 3	Valve modeling: The weights for Valves LCV-113 and -115 were modeled 45% low for valve bodies and 8% low for valve operators. In addition, minor differences in the DCP eccentricity calculations were noted.	No *

DCP Analysis	Condition Noted by IDVP	EOI Issued
D. ITR #59(Rev. 1) (Contd)		
6-101, rev. 2	1. Interference: The pipe deflection during a thermal accident mode exceeded clearance available at Supports 40/21R and 40/22R.	No
	2. Support modeling: Support 10/44SL was modeled with an eccentricity from process pipe OD of 4.25 feet instead of 4.5 inches.	No *
	3. Load summary: The coordinate system was incorrectly shown on the flued head load summary.	No
4A-133, rev. 1	SIF modeling: The SIFs for intermediate butt welds on straight pipe were not considered.	No
4-101, rev. 1	1. Valve modeling: The DCP used a 29% lower valve weight for FCV-365 than that shown by the valve drawing. The DCP did not model valve eccentricities for 9 remote-operated valves at 11 locations. Accelerations for FCV-361 were also extracted from an incorrect location by the DCP.	No *
	2. SIF applications: The DCP ME-101 piping analysis program did not apply the taper transition SIF of 1.9 to the elbow side of the valve/elbow interface.	No
2-114, rev. 1	1. SIF application: The DCP did not apply an SIF of 1.8 to account for the butt welds on straight pipe. The DCP applied an SIF of 3.268 at an unreinforced fabricated tee where the IDVP determined that the SIF for this tee should be 4.95.	No

DCP Analysis	Condition Noted by IDVP	EOI Issued
D. ITR #59(Rev. 1) (Contd)		
	The DCP also applied an SIF of 2.0 at a branch connection where the IDVP determined that the SIF should be 2.58.	
	The DCP also applied an SIF of 2.0 at a branch connection where the IDVP determined that the SIF should be 2.58.	
	2. Valve modeling: The DCP modeled 75 pounds for the weight for the 4-inch check valve. The valve drawing shows the weight to be 102 pounds.	No *
7-103, rev. 0	SIF application: The DCP did not apply socket weld SIFs consistently at socket weld elbows. Some were treated as short or long radius elbows having lower SIFs than a socket weld. The DCP also did not use a socket weld SIF of 2.1 for a swage fitting socket weld.	No
8-116, rev. 1	1. SIF applications: The DCP used an SIF of 1.5 at one 3/4-inch branch at node 32. However, the IDVP found that an SIF of 3.34 should have been used.	No
	2. Support locations: A 3-foot difference in location of one of the supports noted.	No *
8-117, rev. 2	1. Valve modeling: The DCP lumped only two-thirds of the total valve weight at the overall center of gravity for valve 9003A. The weight of the valve contents (30 pounds) was neglected.	Yes

DCP Analysis	Condition Noted by IDVP	EOI Issued
D. ITR #59(Rev. 1) (Contd)		
	2. SIF application: The IDVP did not apply SIFs at various locations including the flued head, branch connection and butt weld along straight pipe. The IDVP determined SIFs ranging from 1.9 to 1.5 should be used.	No
	3. Loading input: A 63% difference (as compared to the subsequent DCM value) in design pressure was noted for small portions of piping.	No
4A-111, rev. 0	1. Loading inputs: The vertical Hosgri spectra used by the DCP (based on preliminary input) was lower than that given in the DCM. One of the thermal modes shown in the DCM was omitted from the DCP analysis (based on preliminary input).	No
	2. SIF application: The DCP applied an SIF of 1.9 at a socket weld connection instead of 2.1.	No
8-102, rev. 2	1. Valve modeling: The DCP analyzed Valve 8805B with the operator in the vertical position, but an IDVP field verification found this operator to be in the horizontal position. Also, differences were found for valve center of gravity locations for valves 8805A and 8805B and IDVP. [sic] and for operator support locations.	No *
	2. SIF application: The DCP used a SIF of 2.44 for the 3/4 inch branch on the 8 inch elbow and a SIF of 3.658 was determined by the IDVP. SIFs for two branches (3/4 inch and 2 inch), field verified by the IDVP to be attached to the 8 inch tee, were not included in the DCP analysis.	No

DCP Analysis	Condition Noted by IDVP	EOI Issued
D. ITR #59(Rev. 1) (Contd)		
12-101, rev. 0	1. SIF application: The DCP did not apply an SIF of 1.8 [sic] butt weld on straight pipe locations.	No
	2. Loading input: The DCP Hosgri spectra input (based on preliminary design data) was lower than the IDVP alternately enveloped spectra (based on subsequent DCM values).	No
E. ITR #60 (Rev. ?)		
Calculation #		
A-123 (Rev. 6)	1. In the natural frequency analysis, the tributary weight for the piping on only one side of the anchor was used.	No
	2. The minimum fillet weld size for the stanchion-to-floor plate weld was incorrectly calculated.	No
	3. The pad-to-process pipe weld was not analyzed.	No
	4. Reinforced pad stresses were not examined.	No
S-1087 (Rev. 1)	The stresses in the tee-shoe and its weld to the pipe clamp were not addressed for the friction force loading.	No
A-35 (Rev. 6)	1. The torsional stiffness of one member in the computer model was three times the correct value.	No
	2. The weld between the stanchion and the process pipe was not analyzed.	No
	3. Reinforced pad stresses were not examined.	No

DCP Analysis	Condition Noted by IDVP	EOI Issued
E. ITR #60 (Rev. 1) (Contd)		
Calculation #		
A-79 (rev. 1)	1. An analysis revision sheet was not included.	No
	2. The analysis load sheet did not note that the tributary pipe weight is in local coordinates whereas the remaining loads on the load sheet are in global coordinates.	No
	3. The load case 4 weld stress, which was a controlling condition, was not analyzed.	No
	4. The support frequency in the restrained direction was not addressed for the Revision 1 loads.	No
	5. The stress at the cutout in a plate member not addressed.	No
	6. Stresses in several welds were not addressed.	No
	7. The analysis did not consider the stress in the support immediately adjacent to the process pipe.	No
A-103 (rev. 5)	1. The 10 inch diameter sleeve, on which the support is mounted, was not considered in the natural frequency calculation. The IDVP considered the sleeve to be the most flexible member of the support by engineering judgement.	No
	2. The 1/4 inch groove weld between the existing lug and the process pipe was incorrectly analyzed.	No

DCP Analysis	Condition Noted by IDVP	EOI Issued
E. ITR #60 (Rev. 1) (Contd)		
Calculation #		
	3. The 1/4 inch fillet weld between a member and the existing lug was incorrectly analyzed. The IDVP determined that this weld stress exceeded the allowable by factoring by correct inputs.	Yes (1129)
	4. The Revision 4 sheet was not included.	No
	5. The IDVP field verification noted a weld across the top of a member attached to the process pipe. The DCP drawing did not show this weld.	No *
A-148 (rev. 4)	The DCP did not directly address the support natural frequency. However, by engineering judgement, the IDVP found that the natural frequencies were greater than the required minimum 20 Hz.	No
H-1279 (rev. 3)	1. The stress in the weld between two members [sic].	No
	2. The computer analysis does not use the maximum loads.	No
H-1040 (rev. 2)	1. The stresses in the shear lugs and the attachment welds were not addressed.	Yes (1131)
	2. A list of references was not included.	No
	3. The DCP analysis included a support drawing which showed a weld on two sides of a beam at its attachment to the existing insert. The IDVP field verification indicated an all-around weld on four sides of the beam (i.e. the DCP analysis was conservative).	No *

DCP Analysis	Condition Noted by IDVP	EOI Issued
E. ITR #60 (Rev. 1) (Contd)		
Calculation #		
A-22 (rev. 5)	1. The maximum combination of loads was not analyzed.	No
	2. The stress in the pipe attachment adjacent to the process pipe and in the attachment-to-process weld were not analyzed.	No
H-1052 (rev. 3)	The stresses in the shear lugs and lug-to-process-pipe weld were not specifically addressed.	No
H-1054 (rev. 3)	Member 3 (3x3x3/8 angle) was not analyzed for stress.	No
H-359 (rev. 4)	1. The length-to-thickness ratio (buckling) of a 2x2x3/8 angle member was not addressed.	No
	2. The stresses in the welded attachment and its weld to the process pipe were not addressed.	Yes (1131)
S-274 (rev. 3)	1. An analysis revision sheet was not included.	No
	2. An incorrect load was input into the computer analysis.	No
	3. Several differences were noted between the drawings and as-built conditions.	No *
	4. The analysis did not consider the cutout in a member (a built-up section of WF and angle members). Affected are the stress in the member and the frequency of the support in the X direction.	No

DCP Analysis	Condition Noted by IDVP	EOI Issued
E. ITR #60 (Rev. 1) (Contd)		
Calculation #		
	5. The stress in the computer model members 116 to 123, 126, 128 to 133, 141, 142 and 151 to 156 were not explicitly evaluated to AISC criteria.	No
	6. The drawing does not reference another support which is mounted on Support 85N/31R.	No *
	7. The local reduced cross section of a member was not considered in the frequency of the support and in the stress analysis of the member.	No
	8. The weld having the highest stress was not analyzed.	No
	9. The local bending of a plate was not analyzed.	No
	10. The pipe welded attachments and their welds were not addressed.	No
H-32 (rev. 5)	1. The support frequency in the unrestrained direction was not addressed.	No
	2. The support frequency in the restrained direction did not consider the flexibility of the stanchion.	No
	3. The bending and axial stresses were interchanged in the stress interaction equation.	No
	4. The Civil Verification Transmittal sheet (notifies the civil group of support loads > 500 pounds) was not included.	No

DCP Analysis	Condition Noted by IDVP	EOI Issued
E. ITR #60 (Rev. 1) (Contd)		
Calculation #		
	5. The revision sheet was not included.	No
	6. The IDVP field verification noted a 1/4 inch plate between the baseplate and Member 9 which was not shown on the support drawing (no impact).	No *
S-245 (rev. 5)	1. There was insufficient documentation to verify the displacement value on which the frequency was based.	No
	2. The frequency analysis did not consider all the flexible members in the support.	No
	3. Incorrect acceleration values were used in the analysis.	No
	4. The pipe clamp was not stress analyzed.	No
	5. The analysis of a weld did not consider one moment.	No
	6. The stresses in the shear lugs and their welds were not addressed.	No
MP-398 (rev. 2)	1. The stress of Member B (1/4 inch plate) was not addressed.	No
	2. The torsional stress calculation of Member 7 (3x3x3/8 angle) did not use the member thickness.	No
	3. The analysis incorrectly computed a shear area for a clevis.	No
	4. The analysis did not consistently incorporate the evaluation of increased design loads.	No

DCP Analysis	Condition Noted by IDVP	EOI Issued
E. ITR #60 (Rev. 1) (Contd)		
Calculation #		
MP-155 (rev. 3)	The maximum stress was reported as approximately half the maximum stress found by the IDVP in the STRUDL analysis.	No
MP-306 (rev. 2)	A moment load was omitted in the analysis of the critical weld.	No
MP-249 (rev. 2)	1. The weld stress analysis used incorrect values for the MX load and for the section modulus.	No
	2. Certain member and weld stresses for Load Cases 1 and 2 were evaluated against incorrect allowables (i.e., based on Load Cases 3 and 4).	No
	3. The IDVP field verification noted that one of the four restraints comprising this support was a small box frame bilateral rather than a tee-shoe and clamp assembly as shown on the DCP support drawing.	No *
MP-983 (rev. 1)	1. Loads provided by the applicable piping analyses did not appear, in all cases, to be those used in the support analyses.	No
	2. Determination of loads at overlap supports was not addressed.	No
	3. There were some discrepancies in the member properties used in the hand calculations (e.g., torsion constant for Member 52).	No
	4. Discrepancies were noted in some weld section properties and in some member properties (e.g., for the majority of the frame, the properties used were for M4x13 instead of W4X13).	No

DCP Analysis	Condition Noted by IDVP	EOI Issued
E. ITR #60 (Rev. 1) (Contd)		
Calculation #		
M-178 (rev. 2)	1. The analysis used a shear area of the full channel in calculating the stress in the channel, rather than using just the web area consistent with each direction.	No
	2. Welded attachments (lugs) and their welds to the process pipe were not evaluated.	No
	3. The analysis erroneously calculated and compared the frequency in the restrained direction to an incorrect value.	Yes (1139)
7-301 (rev. 0)	1 Preliminary thermal operating modes were used by DCP in Revision 0. Revision of this analysis used values from the subsequent DCM.	No
	2. An SIF of 1.3 (instead of 2.1) was applied at two socket weld locations without appropriate DCP field verification documentation. Also, at one location, an SIF = 1.0 (instead of 2.1) was applied for a half coupling.	No
	3. One piping geometry modeling difference (location of data point 40A) between the computer model and the walkdown isometric was identified.	No *
8-305 (rev. 1)	From the IDVP field verification, unintentional restraints were not shown on the PGandE isometric.	No *

DCP Analysis	Condition Noted by IDVP	EOI Issued
E. ITR #60 (Rev. 1) (Contd)		
Calculation #		
8-306 (rev. 3)	1. In several cases, pipe geometry modeling differences exceeded DCP tolerances.	No *
	2. The weight of one valve was input as 25.7 lb instead of 50.7 lb.	No *
8-310 (rev. 2)	1. One pipe length, as shown on the DCP walkdown isometric was modeled exceeding the DCP tolerance.	No *
	2. Unintentional restraints, as shown on the DCP walkdown isometric and by IDVP field verification, were not explicitly addressed in the analysis.	No *
	3. Preliminary thermal operating modes were used by DCP in Revision 2. The DCP compared the preliminary data against values in the subsequent DCM and judged these acceptable.	No
8-311 (rev. 4)	1. Differences were noted between the documentation package (e.g. stress isometric) and the computer analysis. These documentation differences were resolved in Revision 5 of this analysis.	No
	2. One three-way support is modeled as a two-way. The analysis did not address the modification.	No *
9-304 (rev. 1)	Thermal operating modes and large bore piping displacements (SAM/TAM) used by the DCP in the analysis were listed as preliminary. Revision of this analysis used values from the subsequent DCM.	No

DCP Analysis	Condition Noted by IDVP	EOI Issued
E. ITR #60 (Rev. 1) (Contd)		
Calculation #		
9-307 (rev. 1)	The weight of a valve and a branch in the overlapped region were not modeled in the analysis.	No *
10-301 (rev. 2)	1. Thermal operating modes, large bore displacements (SAM/TAM) and containment dilation movements were based on preliminary data. Revision of this analysis used values from subsequent DCMs and other controlled documents.	No
	2. The analysis did not address valve operator support requirements. Revision of this analysis was performed to address this subsequent DCP procedural requirement.	No
	3. At four locations, an SIF = 1.0 (instead of 2.1) was specified for couplings.	No
	4. The weight of insulation for a portion of the pipe was not considered in the analysis.	No *
3-303H (rev. 3)	1. It was noted that the walkdown isometric and analysis considered the line to be insulated, whereas the IDVP found it to be uninsulated.	No *
	2. A short segment of pipe up to the code break valve was 431 degrees Fahrenheit, which exceeded the recommended span rule temperature range. The DCP analysis adequately considered these temperature effects.	No
	3. The effects of X, Y, and Z displacements were considered separately rather than considering the resultant displacement perpendicular to the pipe span for pipe flexibility evaluation.	No

DCP Analysis	Condition Noted by IDVP	EOI Issued
E. ITR #60 (Rev. 1) (Contd)		
Calculation #		
	4. Components such as valves and elbows were considered to have the same flexibility as the pipe for the thermal flexibility evaluation of a short run of pipe.	No
	5. The response spectral acceleration of auxiliary building flexible slabs was not considered in the analysis.	No
	6. The seismic stress acceptability was not specifically documented in the analysis.	No
6-301H (rev. 3)	1. A short segment of pipe up to the code break valve was 365 degrees Fahrenheit, which exceeded the recommended span rule temperature range. The DCP analysis adequately considered these temperature effects.	No
	2. The valve weight (one case) shown on the valve drawing was greater than that used in the analysis.	No *
	3. The equivalent weight used to determine a seismic span containing concentrated weights was incorrectly calculated.	No
	4. Support loads due to SAM/TAM for one support were not summarized on the small bore hanger review sheet.	No
	5. The effects of an anchor in the non-seismic portion of the piping were not evaluated for pipe flexibility considerations. (See EOI 1142 below.)	Yes
9-327H (rev. 2)	The analysis underestimated the design loads and effective weight at one support.	No *

DCP Analysis	Condition Noted by IDVP	EOI Issued
E. ITR #60 (Rev. 1) (Contd)		
Calculation #		
19-307H (rev. 2)	1. A portion of the pipe was 280 degrees Fahrenheit which exceeded the recommended span rule temperature range. However, the temperature used in the DCP analysis for this piping was 120 degrees Fahrenheit.	No
	2. Documentation was not provided for the active valve acceleration qualification.	No
	3. Support loads due to SAM/TAM for one support were not summarized on the small bore hanger review sheet.	No
F. ITR #63 (Rev. 1)		
Analysis #		
HV-59	The IDVP field verified that only three of the five analyzed supports existed in the field (-05, -07 and -13). Support 07 was analyzed as the worst case support with a duct tributary length of 15.75 feet.	No *
HV-88	The IDVP review of HV-88 resulted in the issuance of EOI 1143 citing the misapplication of seismic coefficients.	Yes
HV-104	Ceiling connection detail for support 59357-38 shows a gap under a ceiling mounting plate. The methodology used to analyze the plate did not adequately account for the gap.	No *
HV-116	DCP sketches and as-built data did not correlate with the support analysis. In addition, DCNs for modifications were omitted from the documentation package.	No *

DCP Analysis	Condition Noted by IDVP	EOI Issued
F. ITR #63 (Rev. 1) (Contd)		
Analysis #		
HV-119	Analysis did not include weight of insulation in determining duct frequency.	No
HV-81 HV-86 HV-87 HV-96	EOI 1134 was issued as a result of the IDVP review of the DCP Corrective Action Program. The DCP used an approximate procedure to determine a response frequency based on the Rayleigh-Ritz method as performed by the ICES STRUDL II computer code. This procedure was used for the seismic analysis of HVAC ducts and supports. The EOI was issued because, in some cases, frequencies reported by the DCP were significantly different from those alternately calculated by the IDVP. This difference occurred because the DCP frequencies did not always correspond to the first mode natural frequency.	Yes
S-80B	1. The design analysis did not consider the support deadweight.	No
	2. The design analysis did not explicitly evaluate column stability.	No
S-262	One of the as-built supports had a member length slightly longer than the length used.	No *
S-314	The dead analysis did not consider the support deadweight.	No
S-356	1. The generic calculation was not based on maximum generic conduit weight as required by DCM C-15, Revision 3.	No
	2. Stresses at key support connections were not evaluated.	No
	3. The analysis did not account for the manufacturer's allowables in the analysis of Unistrut.	NO

DCP Analysis	Condition Noted by IDVP	EOI Issued
F. ITR #63 (Rev. 1) (Contd)		
Analysis #		
S-562	Analysis neglected deadweight of the support structure and did not apply peak accelerations. However, the DCP analysis used twice the approximate weight of the attached box.	No
S-623	The DCP computer model did not fully account for proper boundary conditions and for all restraint reactions.	No
(Field Verification of Corrective Action)	The IDVP field verification determined that a conduit clamp modification for support CSR-127-6-471 had been incorrectly implemented. DCN DCT-EC-3604, Revision 0, specifies changing a conduit clamp on conduit K7218 based on Analysis ACSR-127-T1. The IDVP field documentation (Reference 8A) shows the new clamp to be on conduit K8375, which is adjacent to conduit K7218.	No *
ITS-2 (rev. 1)	The IDVP reviewed ITS-2 using a written checklist. The results of the review indicate that ITS-2 does not follow the established DCP analysis methodology.	No
ITS-4 (rev. 1)	1. Incomplete support weight.	No
	2. Unreferenced seismic acceleration coefficients are lower than the latest spectra acceleration values.	No
	3. Analytical methods which may have provided unconservative results.	No
ITS-5 (rev. 1)	Of the seven support analyses, one support used an assumed member size and section property which did not agree with the as-built member size.	Yes * (1123)

DCP Analysis	Condition Noted by IDVP	EOI Issued
F. ITR #63 (Rev. 1) (Contd)		
Analysis #		
ITS-6 (rev. 1)	1. One support type did conform to DCP as-built information.	No *
	2. Two of the supports analyzed no longer exist.	No
	3. Four of the supports carried loads greater than those used in the DCP analysis.	No *
	4. One support could not be located in the field.	No *
(Field Verification)	Four of sixteen supports were found to carry loads greater than those documented by the DCP.	No *
U-131	The DCP effective length (13.1 inches) differs from the IDVP alternate calculation (28 inches).	No
U-192	The analysis assumed that the closed loop double U-bolt was fixed at midlength. This resulted in an effective gap which led to a pipe rupture load that exceeded the established NSC allowable.	No
U-313	The DCP rod effective length (48 inches) differs from the IDVP alternate calculation (91 inches).	No
U-355	The DCP U-bolt effective length (103 inches) differs from the IDVP alternate calculation (87 inches).	No

DCP Analysis	Condition Noted by IDVP	EOI Issued
F. ITR #63 (Rev. 1) (Contd)		
Analysis #		
(DCP test program for U-bolt connectors)	The DCP test program is responsive to the IDVP QA finding noted in ITR #42. Based on negative test results, several design modifications have been planned and implemented. In particular, the nuts and couplers are being replaced with split wedge designs. During the connector testing, the DCP noted a concern with the ductility of the U-bolts and rod beams. DCP Open Item 42 has been issued to track this ongoing work.	No
S-20	1. The adequacy of the baseplate was not explicitly addressed in the analysis.	No
	2. A dynamic impact factor of 1.8 was not applied.	No
S-30	1. The stresses in one key member were not evaluated.	No
	2. The adequacy of the base plate connections was not evaluated for plastic moment transmitted through coped flange joints.	No
S-130	The analysis did not explicitly apply a 1.8 dynamic impact factor or evaluate the rock bolts.	No
S-150	1. The concrete shear cone area was underestimated by 50% in the design analysis.	No
	2. The adequacy of the base plate connections was not evaluated for plastic moment transmitted through coped flange joints.	No

DCP Analysis	Condition Noted by IDVP	EOI Issued
F. ITR #63 (Rev. 1) (Contd)		
Analysis #		
S-240	1. The design analysis incorrectly calculated the allowable values for the bearing plate.	No
	2. The DCP incorrectly calculated the fundamental frequency in the plane normal to the frame.	No
	3. The capacities of the through bolts were not evaluated.	No
S-260	1. The design analysis incorrectly analyzes the weld stress in a column plate.	No
	2. Rock bolts were evaluated using a dynamic impact factor of 1.25 rather than 1.8.	No
	3. The coupled U-bolt/substructure analysis results were incorrectly evaluated.	No
S-329	1. The endmost line loads were modeled incorrectly in the analysis.	No
	2. The design analysis does not evaluate the anchor under rupture loads from each of the 5 pipe lines and all 6 load components of a single pipe rupture.	No
S-331	1. Two of the bolts in the four bolt plate joint between two column members had been cut out to prevent pipe movement interference. The impact of the reduced section was not evaluated.	No *
	2. Bolts connecting beam base plate to embedded plate were not evaluated for shear stresses developed between the plates.	

TABLE 8-1

TABLE 8-1

ERRORS IDENTIFIED IN DESIGN PRODUCT REVIEW
(Design Modifications Since November 1, 1981)

	Description of Error	Appendix B Criteria *	EOI Reference	Error Class
1.	Differences disclosed between "as analyzed" and "as-built" bolt sizes.	3,6,10,16	EOI 1120 EOI 1121	Error C
2.	Differences disclosed between "as-built" and "as-analyzed" instrument tubing support.	3,6,10,16	EOI 1123	Error C
3.	Design analysis finite element model of the control room slab used to generate Hosgri spectra does not agree with the field verified location of the supporting wall.	3,6,10,16	EOI 1124	Error B
4.	Revision 1 of the HVAC compressor seismic calculation used incorrect and unconservative spectra.	3,6,16	EOI 1125	Error C
5.	DCP used improper stress intensification factors (SIF).	3,6,16	EOI 1126, EOI 1138	Combine w/ EOI 1098 (Error A/B)
6.	Deficiencies in DCP reanalyses of station battery racks regarding bolt diameter and resolved shear force.	3,6,10,16	EOI 1128	Error C

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* The designation of Appendix B criteria relevant to the identified deficiencies is intended to highlight the major QA/QC criteria violated and, as such, is not intended to be an exhaustive list. The preceding limitation is necessary also because of the high degree of interrelationship between a number of the criteria of Appendix B.

	Description of Error	Appendix B Criteria *	EOI Reference	Error Class
7.	Errors in the design reanalyses for large bore pipe support 565/3A.	3,6,16	EOI 1129	Error C
8.	Reanalyses of large bore pipe supports not evaluated as required by the DCP procedure.	3,6,16	EOI 1131	Deviation
9.	Failure to perform an evaluation of Auxiliary Building slabs for in-plane loadings contrary to the PG&E Final Report dated May 18, 1983.	3,6,16	EOI 1132	Combine w/ EOI 1097 (Error A/B)
10.	Incorrect valve modeling in DCP seismic reanalyses.	3,6,16	EOI 1133, EOI 1135, EOI 1137	Combine w/ EOI 1098 (Error A/B)
11.	Use of incorrect bolt allowable stress in the DCP reanalysis.	3,6,16	EOI 1136	Error C
12.	Error in the design analysis calculation of frequency of a small bore pipe support.	3,6,16	EOI 1139	Error C
13.	DCP analysis failed to examine the discharge nozzle flanged joint. As-built configuration does not conform to PG&E piping specification.	3,6,10,16	EOI 1140	Error C
14.	DCP failed to identify all high energy lines inside and outside containment.	3,6,16	EOI 1141	Combined w/ EOI 1098 (Error A/B)
15.	Pipe support loads due to the effects of various loading combinations not considered in the design analysis contrary to the DCP design criteria procedure.	3,6,16	EOI 1142	Error C

	Description of Error	Appendix B Criteria *	EOI Reference	Error Class
16.	DCP analysis does not correctly consider the effect of the revised vertical and horizontal Hosgri spectra.	3,6,16	EOI 1143	Error C
17.	Design analyses performed to generically qualify vents and drains may not be conservative.	3,6,16	EOI 1144	Error C
18.	Hosgri design response spectra for the containment interior structure developed by DCP does not envelope raw spectra developed by the IDVP.	3,6,16	EOI 3009	Error C