UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION '83 DEC 29 A10:34

BEFORE THE ATOMIC SAFETY AND LICENSING APPEAL BOARD

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

PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW OF GOVERNOR DEUKMEJIAN

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PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW OF GOVERNOR DEUKMEJIAN

Governor George Deukmejian hereby respectfully submits the following Proposed Findings of Fact and Conclusions of Law on Design Quality Assurance.

DATED: December 23, 1983

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TOPICAL INDEX

INTRODUCTION

In 1968 and 1970, respectively, applicant Pacific Gas and Electric Company (PG&E) was authorized to construct Units 1 and 2 of the proposed Diablo Canyon Nuclear Power Plant in San Luis Obispo County, California. (Docket No. 50-275, 4 AEC 89; Docket No. 50-323, 4 AEC 447.)

By 1981, following modifications in response to discovery of the Hosgri Fault less than two miles from the plant, Unit 1 was reaching completion. On July 17, 1981, the Atomic Safety and Licensing Board issued a partial initial decision authorizing issuance of a license to load fuel and test Unit 1 at up to 5 percent power. (Pacific Gas and Electric Company (Diablo Canyon Nuclear Power Plant, Units 1 and 2), LBP-81-21, 14 NRC 107.) One of the issues addressed in that decision was the adequacy of PG&E's quality assurance (QA) program, which the Licensing Board resolved in two pages with a finding that the Diablo Canyon QA program for design, construction, and operation "have been and are in compliance with" 10 C.F.R. Part 50, Appendix B (Appendix B). (14 NRC at 116.)

The Nuclear Regulatory Commission (Commission) authorized immediate effectiveness of that decision (Pacific Gas and Electric Company (Diablo Canyon Nuclear Power Plant, Units 1 and 2), CLI-81-22, 14 NRC 598 (1981)), and on September 22, 1981, the Staff issued to PG&E License No. DPR-76 authorizing loading and low-power testing of Unit 1.

Within days of the issuance of the low-power license, an error in the seismic design of Unit 1 was discovered. It was subsequently learned that the error had been caused by the transmission to a PG&E design contractor of an unidentified drawing of Unit 2 that was taken by the contractor to be for Unit 1. Since the two units are mirror images

of one another, the error (the mirror-image error) led to the errors in the placement of certain seismic modifications. Shortly after the discovery of the mirror-image error, several additional errors were discovered that led the Commission to conclude that there had been serious shortcomings in the QA program for Diablo anyon in violation of Appendix B and that there was doubt that statements made in the license application regarding the ability of structures, systems, and components (SS&Cs) to withstand the effects of earthquakes may not have been true. The Commission therefore entered an order (Commission Order) suspending the license on November 19, 1981. (Pacific Gas and Electric Company (Diablo Canyon Nuclear Power Plant, Unit 1), CLI-81-30, 14 NRC 950.) In suspending the license, the Commission established requirements for restoration of the license, including the satisfactory completion of an "independent design verification program" (IDVP). (Commission Order, Attachment 1.) The Staff issued on the same date a letter (Staff Letter), supplementing the requirements for the IDVP.

The IDVP was established, with Teledyne Engineering Services (Teledyne) retained as the program manager. In addition, PG&E hired Bechtel Power Corporation (Bechtel) and formed a joint management team and supporting technical organization, called the Diablo Canyon Project (DCP) to complete the project. The DCP conducted what it calls the Internal Technical Program (ITP) to carry out PG&E's verification responsibilities.

On June 7, 1982, the Joint Intervenors (JI), a consortium of interested local parties, moved to reopen the record on design quality assurance, citing the mirror-image error and the errors that followed. A similar motion was filed on August 16, 1982, by Governor Edmund G. Brown on behalf of the State of California. On January 3, 1983, George Deukmejian

succeeded Governor Brown, and on January 28, 1983, Governor Deukmejian filed a Notice of Substitution, assuming representation of California. The motions to reopen were opposed by PG&E and by the Nuclear Regulatory Commission (NRC) Staff. However, both the applicant and Staff subsequently withdrew their opposition, and on April 21, 1983, the Board issued an order reopening the record on the issue of design quality assurance.

On July 19, 1983, at the Board's direction, the Governor and Joint Intervenors filed "specifications of the precise matters they contest in the reopened proceeding." (Order of July 6, 1983.) Applicant and the Staff objected to a number of those issues on the ground that they failed to meet the basis and specificity requirements of 10 C.F.R. section 2.714(b); PG&E also disputed the relevance of the IDVP and the right of the other parties to challenge its adequacy.

The Board indicated in its Order of August 16, 1983, and confirmed in an Order of August 26, 1983, their view that the evidence that led to the reopening of the record, agreed to by PG&E and the Staff and concurred in by the Board, established the basis for the reopened proceeding and stood in the place of the "contentions" required by section 2.714(b). (Order of August 16, 1983, pp. 2-4.)

The Board went on to note the unusual nature of the proceeding:

> "Normally, an effectively functioning design quality assurance program ensures that the design of a nuclear power plant is in conformance with the design criteria and commitments set forth in an applicant's PSAR and FSAR. In the case of Diablo Canyon, however, this confidence has been seriously eroded by the existence of significant evidence that the design quality assurance program was faulty (i.e., it failed to comply with 10 C.F.R. Part 50, Appendix B). Hence, there is now substantial uncertainty whether any particular structure, system or component was designed in accordance with stated criteria and commitments.

"In these circumstances, the Commission mandated the IDVP to provide after-the-fact assurance that the Diablo Canyon design conformed to the various design criteria and could receive an apparently operating license even though the applicant apparently failed to comply adequately with the Commission's quality assurance regulations. The applicant established its ITP for the same purpose. These verification activities, if properly conceived and carried out, are to substitute for, and supplement, the applicant's design quality assurance program in order to demonstrate that the Diablo Canyon plant is correctly designed . . . .

". . . The real issue in the reopened proceeding has, in effect, moved beyond the question of what deficiencies existed in the applicant's Diablo Canyon design quality assurance program to the question whether the applicant can demonstrate that the IDVP and the ITP verify the correctness of the Diablo Canyon design. As previously stated, this is necessary because the apparent weakness of the applicant's design quality assurance program has rendered the design of the plant's structures, systems and components suspect. The applicant's use of the IDVP and ITP therefore may be loosely analogized to an affirmative defense to the apparent failure of the Diablo Canyon design quality assurance program to comply with the Commission's regulations. As such, the applicant has both the burden of going forward and the burden of proving the adequacy of the IDVP and ITP to establish that the plant is properly designed . . . ." (Order of August 16, 1983, at 4-6 (fn. omitted).)

On September 7, 1983, the Board issued an order setting forth the issues to be litigated. The Governor and Joint Intervenors filed additional contentions concerning late-developing issues, principally regarding the final technical reports of the IDVP, which the Board approved.

In the course of discovery, the Governor and Joint Intervenors came to be satisfied with the resolution of a number of issues, which they withdrew. The final set of issues they litigated is given in Appendix A to these Findings of Fact and Conclusions of Law.

Fifteen days of hearings were held October 31 through November 21, 1983, at Avila Beach, near the power plant site in San Luis Obispo County. Forty-one witnesses testified and are identified in Appendix B. The Board admitted 141 exhibits into evidence, which are identified in Appendix C.

FINDINGS OF FACT

I.

THE IDVP HAS FAILED TO PROVIDE ASSURANCE THAT THE DESIGN OF DIABLO CANYON UNITS 1 AND 2 CONFORMS TO THE LICENSING CRITERIA AND REGULATORY REQUIREMENTS

A. To Meet the Requirements for a Verification Program, the Applicant Must Show Either That the Design Fully Conforms to Licensing and Regulatory Requirements or That the Design has Been Subjected to the Same Level of Scrutiny it Would Have Received Under an Adequate QA Program

1. Under the Commission's regulations, in order to qualify for a license an applicant must demonstrate that it has constructed the plant "in conformity with the construction permit and the application as amended, the provisions of the [Atomic Energy] Act, and the rules and regulations of the Commission . . . ." (10 C.F.R. § 50.57(a)(1).)

2. In evident understanding of this requirement, the IDVP, with the approval of the Commission, established a system for identifying and classifying design errors. That system distinguished errors that did not have regulatory significance from those that caused the design to deviate from the licensing criteria. Thus, the IDVP identified a questionable aspect of the design as an "error/open item" (EOI), and, if it was confirmed that a given EOI was in fact the product of an error, categorized the error as an "error class A, B, C, or D." (IDVP Final Rep., PG&E Exh. 90, pp. F.2-4 - F.2-5.) An error class A, the most serious category of error recognized by the IDVP, caused "design criteria or operating limits of safety related equipment [to be] exceeded," requiring physical modification or changes in operating procedures. (Id., at F.2-4.) A class B error likewise caused safety-related design criteria or operating

limits to be exceeded, although the deviation might be resolvable "by means of more realistic calculations or retesting." (Id., at F.2-5.) By contrast, class C and D errors were the result of erroneous engineering that produced a design that still complied with licensing requirements. (Id., at F.2-4.) Thus, the structure adopted by the IDVP was well suited to determine whether Diablo Canyon Unit 1 met the requirement of section 50.57 that it conform to all licensing and regulatory requirements.

(1) The IDVP and the Staff Made Contradictory Claims as to Whether the Verification Program Demonstrated That the Design Conforms to the Licensing Requirements

3. The IDVP made contradictory claims regarding the results of the verification program:

(a) In the IDVP Final Report, it is stated that the IDVP "has effectively identified uncertainties in the compliance of the design with license application criteria." (IDVP Final Rep., PG&E Exh. 90, pp. ES-7, 2.0-1.) The report also states that ". . . the scope of the IDVP review was sufficient, and the procedures utilized to identify concerns effective, to provide reasonable assurance that those aspects of the design work on DCNPP-1 performed by PG&E or service-related contractors which did not meet the license application criteria have now been identified." (Id., pp. 6.2.5-1 - 6.2.5-2.)

(b) At the same time, the IDVP Final Report disclaimed having "identified each and every error or questionable aspect of the design product of PG&E and its contractors or the design process they utilized." (Id., p. 6.2.5-2.)

(c) In its prepared testimony, the IDVP testified that the scope of its program was adequate "to provide reasonable assurance that those

aspects of the DCNPP-1 design which did not meet the criteria of the license application have been identified." (IDVP Panel 1, ff. Tr. D1458, at 1/2-31.) But the next page of its prepared testimony contains the following:

> "Q.27 Does this mean that the IDVP identified each and every deficiency in compliance with the criteria of the license application?
>
> "A.27 No. The IDVP was not intended to do this, nor could any reasonable independent verification program. . . ." (Id., at 1/2-32.)

4. Similarly, the staff evaluation of the IDVP is contradictory on whether or not compliance with the license has been assured:

(a) In SSER 18, ". . . the Staff concludes (1) that the verification efforts undertaken have identified all significant design deficiencies that may have existed and (2) . . . appropriate corrective actions have been and will be taken to ensure that the design of the facility conforms to the licensing criteria."

(b) At the hearing, Mr. Schierling, Diablo Canyon project manager for the Staff, testified that the goal of the IDVP, against which it may be measured, is the demonstration that all deviations from the licensing criteria have been corrected. (Tr. D2654-55.) But Mr. Knight, Staff Assistant Director for Components and Structures Engineering, testified that the IDVP was only required to assure that there remain no "significant deviations from licensing criteria." (Tr. D2656.) He defined "significant deviations" as violations of licensing criteria that would cause a loss of function of a safety-related structure, system, or component. (Tr. D2657.) Mr. Knight could cite no authority in the regulations for the Staff failing to require compliance with

license criteria on the ground of a claimed determination that a deviation had no safety significance. (Tr. D2659.) In deposition Mr. Schierling had used the term "significant design deficiencies" as equivalent to error class A or B. (Tr. D2831-35.)

(c) Both Mr. Knight and Mr. Schierling acknowledged at the hearing that the IDVP did not establish the absence of any remaining deviations from licensing criteria, merely that there are none that would, in the Staff's view, amount to a "significant deviation." (Tr. D2655, D2705.)

5. In fact, as we find below, neither the IDVP nor the ITP (which are collectively referred to as the "verification program") demonstrated that the design of the plant meets all licensing criteria. Indeed, they proved the contrary: that it is virtually certain there remain numerous undetected design errors that cause the design to violate applicable licensing criteria.

(2) The Fact That a Lawful QA Program Would not Guarantee an Error-Free Design Does not Render the Existence of Uncorrected Errors Irrelevant

6. In an effort to respond to the evidence of remaining errors, PG&E has cited the fact that even a plant designed with a legally sufficient QA program in operation will likely have some design errors. (PG&E Exh. 89, pp. 13-14; Hubbard, ff. Tr. D2084, at 11; Tr. D2130, D2369-73.)

7. However, there is no basis for comparing the numerical results of the verification program with the design quality of other plants in the country becuse there exists no numerical standard for the error rate of a design that was subject to an adequate QA program. (Apostolakis, ff. Tr. D2313, at 9-10, 19-20; Tr. D2715.)

8. Mr. Hubbard testified that the objective of a QA program is

not to achieve any specific maximum number of residual errors; instead, confidence in the design is a product of the QA process itself, the knowledge that if one satisfies the 18 criteria of Appendix B, one can have an adequate confidence in the design product. (Tr. D2135.)

9. One requirement of Appendix B is that suitable design control procedures be established and implemented. (Criterion III.) The design control procedures properly will include a 100 percent review of all design work by a second designer or engineer plus approval of all work by a supervisor. (Tr. D401.) This requirement of Criterion III of Appendix B is in addition to the required inspections (Criterion X), audits (Criterion XVIII), and corrective action measures (Criterion XVI).

10. The Board finds that, since it is impossible to establish the adequacy of the design by comparing the number of errors to the number of errors to be expected in a plant designed with an adequate QA program, an after-the-fact verification can establish the adequacy of a given portion of the design in two ways: (1) by demonstrating that that portion of the design is error-free or (2) by subjecting that portion of the design to the same review it would have been subjected to had there originally been an adequate QA process in effect.

B. The IDVP has Failed to Show Either That the Design Fully Conforms to Licensing and Regulatory Requirements or That the Design has Been Subjected to the Same Level of Scrutiny it Would Have Received Under an Adequate QA Program

(1) It Is Virtually Certain There Remain Undetected Errors That Cause the Design to Fail to Comply With the Licensing Criteria

11. The only quantitative results of the IDVP's verification of the non-seismic design were reported by Dr. Kaplan, the DCP's expert witness on "probabilistics" (Tr. D1333), who reviewed the results of the

IDVP's non-seismic verification work and found nine class A or B errors in 911 design elements sampled by the IDVP. (PG&E Panel 6, ff. Tr. D1160, at 48.)

12. If one assumes this was the result of a random sample of the design work, Dr. Kaplan estimates that the median error rate for the non-seismic design work is about 1.3 percent. (Id., at p. 51; Tr. D1168.)

13. Extrapolating the median error rate for the IDVP sample to the total non-seismic design leads to the conclusion that there remain 40 undetected class A or B errors in the non-seismic design not reviewed by the IDVP. (Tr. D1169.)

14. Although Dr. Kaplan testified that the IDVP sample was weighted in favor of that portion of the design where errors were more likely (Tr. D1167), which would militate in favor of a lower estimated number of remaining class A or B errors (Tr. D1169-71), the evidence was clear that Dr. Kaplan was in error in his understanding of the objectives of the IDVP's selection of an initial sample. In fact the IDVP asserted no such objective in its selection of the sample (IDVP Final Rep., PG&E Exh. 90, p. 4.7.1-1; IDVP Panel 1, ff. Tr. D1458, at 1/2-21), and Dr. Cooper, the IDVP program manager, testified the IDVP did not seek to weigh the sample in favor of that portion of the design most likely to have errors (Tr. D1549). Indeed, both Dr. Cloud and Dr. Cooper testified that one could not know a priori where errors were most likely to occur. (Tr. D1547, D1549.)

15. In addition to the certainty that there remain undetected class A or B errors in the non-seismic design work, Dr. Cloud testified that it is very likely there remain undetected class A or B errors in the

corrective action program work. (Tr. D1543.)

(2) The IDVP has not Subjected the Design to the Same Level of Scrutiny That it Would Have Received Under an Adequate QA Program

(a) The IDVP's verification of the seismic design consisted of a sampling of the ITP design review work

16. The IDVP program management plan for Phase I originally contemplated sampling the seismic design of Unit 1 to determine the nature and extent of any design errors. (PG&E Exh. 88, pp. 8-9; DCP Phase I Final Rep., PG&E Exh. 91, pp. 1.5.2-1 - 1.5.2-2.)

17. By June 1982, the extent of the design errors identified in Phase I led to a change in the program, with the DCP instituting a 100 percent review of the seismic design and the IDVP verifying that work on a sample basis. (ITR 8, PG&E Exh. 100; IDVP Panel 1, ff. Tr. D1458, at 1/2-12 - 1/2-13.)

18. The samples drawn by the IDVP for verification were not drawn at random but rather purposefully, according to what the IDVP called "engineering judgment." (PG&E Exh. 88, Appen. D, p. 12.)

19. Because, as we have found, a legally sufficient QA program would have subjected 100 percent of the design work to review, the Board finds that the IDVP's verification of the seismic design of Unit 1 does not constitute a substitute for having subjected that portion of the design to an adequate QA program in the first instance.

(b) The IDVP's verification of the non-seismic design consisted of a sample of certain parts of the original non-seismic design work

20. Unlike the seismic design review, where PG&E undertook a broad review of the design product that was sampled by the IDVP, the

non-seismic review consisted of a review by the IDVP of a sample of the original design work done by PG&E and certain of its contractors.

(i) The IDVP failed to verify the work of contractors performing safety-related design work.

21. The IDVP was required to review the safety-related design work of all service contractors for Unit 1. (Commission Order, PG&E Exh. 86, Attach. 1; Staff Letter, PG&E Exh. 87, pp. 2-3, encls. A, C.)

22. The IDVP developed a list of safety-related service contractors who contributed to the final design of Unit 1. (IDVP Final Rep., PG&E Exh. 90, § 4.1.4; ITR 5, PG&E Exh. 97; ITR 9, PG&E Exh. 101; ITR 29, PG&E Exh. 121.)

23. The IDVP selected some of those contractors for verification and omitted others. (IDVP Final Rep., PG&E Exh. 90, p. 4.1.4-3.) The elimination of service-related contractors was not authorized by the Commission and was objected to by the Staff. (SECY-82-414, PG&E Exh. 157, encl. 6, p. 4.) Staff approval of the IDVP expressly restated the requirement that "all" service-related contractors be included. (SECY-82-414, PG&E Exh. 157, Figs. 1, 3, encl. 6, p. 4; Tr. D2755.) A subsequent objection by the IDVP to the requirement of including all contractors (Gov. Exh. 47, p. 1) was never responded to by the Staff (Tr. D1468).

24. Dr. Cooper sought to justify the omission of certain contractors on the ground that the Staff Letter permitted the use of sampling. (Gov. Exh. 47; Tr. D1462.) However, the letter authorizes sampling within the work of each contractor, not sampling among contractors (Staff Letter, PG&E Exh. 87, pp. 2, 3), a distinction the IDVP failed to

draw in planning and carrying out its program (Tr. D1469).

25. Among the contractors excluded from the IDVP's verification were the following:

-- Westinghouse, which, in addition to being the vendor for the nuclear steam supply system (NSSS), did safety-related design work. (Tr. D1471-77.) IDVP review of Westinghouse was limited to checking the design interface between PG&E and Westinghouse. (Tr. D1477.)

-- Western Canada Hydraulic Laboratories, which did safety-related design work. (Tr. D1478) Western Canada had been found by PG&E to have had no formal QA program applicable to its Diablo Canyon work. (SECY-82-414, PG&E Exh. 157, encl. 5, p. 5.)

-- Stafco, which prepared the list of safety-related SS&Cs and participated in updating the FSAR. (Tr. D1486.) Although the IDVP did not consider it design work, its witnesses agreed that the work was safety-related. (Tr. D1488.) PG&E had included Stafco among the list of contractors for the IDVP. (ITR 9, PG&E Exh. 101, p. A46.) PG&E had found Stafco to have had a deficient QA program. (SECY-82-414, PG&E Exh. 157, encl. 5, p. 5.)

26. The IDVP also excluded the work of R. L. Cloud and Associates and Teledyne Engineering Services, which provided safety-related design services. (IDVP Final Rep., PG&E Exh. 90, p. 4.1.4-3; Tr. D1483-85.) The Cloud organization had been found by PG&E to have no formal QA program. (SECY-82-414, PG&E Exh. 157, encl. 5, p. 5; Tr. D1483.) The exclusion of these contractors was based on the need to avoid a conflict of interest, since both were IDVP contractors (IDVP Final Rep., PG&E Exh. 90, p. 4.1.4-3; Tr. D1484), and on the IDVP's interpretation of the Commission

Order and Staff Letter as not requiring inclusion of contractors performing work after June 1978 (Tr. 1484-85).

27. Although Mr. Knight testified that the Staff implicitly intended to permit the IDVP to exclude contractors not significantly contributing to the final design (Tr. D2755), the IDVP did not claim that the foregoing excluded contractors could be omitted on that ground (IDVP Final Rep., PG&E Exh. 90, p. 4.1.4-3).

(ii) The IDVP Sample of PG&E's Non-Seismic Design Consisted of a Non-Random Sample of That Work

28. The IDVP sought to verify that portion of the non-seismic design of Unit 1 for which PG&E performed the design work by taking a sample of the PG&E-designed SS&Cs. (IDVP Final Rep., PG&E Exh. 90, p. 4.7.1-1; IDVP Panel 1, ff. Tr. D1458, at 1/2-21.)

29. The sample was selected from a list of PG&E-designed SS&Cs. (IDVP Final Rep., PG&E Exh. 90, pp. 4.1.2-1 - 4.1.2-2; Tr. D261-62.) Some PG&E-designed SS&Cs were omitted from the list, although some of them may have been included incidentally in the IDVP's verification sample. (Tr. D306-07, D1492, D1496-98.)

30. The IDVP did not select its sample of SS&Cs randomly but rather by purposeful selection of design work that had attributes desired by the IDVP. (IDVP Final Rep., PG&E Exh. 90, pp. 4.7.1-1 - 4.7.1-2; IDVP Panel 1, ff. Tr. D1458, at 1/2-21.)

31. The IDVP sample consisted initially of three systems: the auxiliary feedwater system (AFWS), the 4160-V electrical system, and the control room ventilation and pressurization system (CRVPS). (Ibid.)

32. As a result of "generic concerns" raised in the non-seismic

verification of the three systems, the IDVP caused all applicable safety-related systems in Unit 1 to be reviewed for five specific errors: lack of redundancy in shared-power equipment, incorrect selection of design temperatures and pressures, erroneous environmental consequences of postulated pipe ruptures outside containment, failure to meet circuit-separation criteria, and erroneous analysis of the effects of pipe-ruptures inside containment. (IDVP Final Rep., PG&E Exh. 90, pp. 4.8.1-1 - 4.8.1-3; DCP Phase II Final Rep., PG&E Exh. 92, p. 1-20; IDVP Panel 1, ff. Tr. D1458, at 1/2-24.) The IDVP verified the results of that work on a sampling basis. (DCP Phase II Final Rep., PG&E Exh. 92, p. 1-20.)

33. Although PG&E represented the IDVP non-seismic sample as accounting to 30 percent of the non-seismic design (Tr. D1419), in terms of the total number of "design elements," the IDVP reviewed only 911 out of 3,968 design elements (PG&E Panel 6, ff. Tr. D1160, at 48), or less than 23 percent.

34. The Board finds that the IDVP's non-seismic verification constitutes a satisfactory substitute for an adequate QA program for those contractors sampled by the IDVP. The Board further finds that the IDVP's non-seismic verification is a satisfactory substitute for an adequate QA program for the three systems sampled by the IDVP — the 4160-V electrical system, the AFWS, and the CRVPS -- plus those elements of the non-seismic design reviewed in the IDVP's resolution of the five generic concerns.

35. The Board finds that, with respect to the balance of the non-seismic design, the IDVP review does not constitute a satisfactory substitute for an adequate QA program.

(C) None of the Reasons Given by PG&E for the Board to Ignore its Failure to Meet the Licensing and Regulatory Requirements is Valid

36. PG&E advances a number of grounds for this Board to ignore the evidence of remaining undetected errors causing the design to violate legal requirements and for us to excuse the failure of the verification program to scrutinize the design as fully as an adequate QA program would have. For the reasons given below, we find none of the grounds valid.

(1) The Claim That There Remain no Undetected Errors Having Safety Significance is Unfounded

37. While the evidence is uncontradicted that there remain undetected errors in the design of the facility, PG&E, the IDVP, and the Staff claim that none of the errors is safety-significant. (SSER 18, Staff Exh. 36, pp. C.5-2, C.5-6; IDVP Final Rep., PG&E Exh. 90, p. 6.2.5-2.; PG&E Panel 6, ff. Tr. D1160, at 64-65; D1545, D1558, D2265-66.)

(i) The evidence does not support any conclusion about the safety significance of the errors identified by the verification program

38. The IDVP expressly declined to offer any opinion about the safety significance of the design errors it detected that it classified as causing a violation of the licensing criteria. (IDVP Final Rep., PG&E Exh. 90, p. 6.4-1.) Although one could state one's judgment, the IDVP did not perform the analyses necessary to have a reportable conclusion about the safety significance of the identified errors. (Tr. D1555, 1559.)

39. Both PG&E and the Staff offered opinions about the safety significance of the known design errors, opining that none of them constituted a safety-significant error. (DCP Phase I Final Rep., PG&E Exh. 91, p. 1.8.6-1; DCP Phase II Final Rep., PG&E Exh. 92, p. 5-1; PG&E

Panel 6, ff. Tr. D1160, at 54; Tr. D2696.) This conclusion was not based on any systematic study of the known errors by PG&E or the Staff. (DCP Phase I Final Rep., PG&E Exh. 91; DCP Phase I Final Rep., PG&E Exh. 92; Tr. D2689.)

40. Both Dr. Cooper and Prof. Apostolakis testified that one could not reliably formulate an opinion on the safety significance of an error without doing a detailed analysis. Dr. Cooper testified such an analysis would have to assess whether the error could cause a failure of a system and, if a failure was possible, to identify and evaluate the chain of events following the failure. (Tr. D1555, D1557.) Prof. Apostolakis testified that to properly assess the reduction in the margin of safety caused by a design error, one would have to perform a probabilistic risk assessment (PRA) to determine "failure paths not perceived by knowledgeable engineers" and the potential for multiple failures of redundant components. (Apostolakis, ff. Tr. D2313, at 10-11.) Even Dr. Kaplan testified that a PRA would be the soundest way to assess the safety significance of a design error (Tr. D1393), although both he and Prof. Apostolakis agreed that something less than a "full-blown PRA" would be adequate to assess the risk from certain errors. (Tr. D1394-96, D2374.)

41. No such PRA has been done for Diablo Canyon. (Tr. D1194.)

42. The Board therefore finds that the opinions of PG&E and the Staff to the effect that the identified design errors did not create a substantial safety hazard lack adequate basis to support a licensing decision in this case.

(ii) There is no basis for making any statement about the design errors that remain undetected

43. While the IDVP expressly declined to offer any opinion about

the safety significance of the class A or B errors it did find (Tr. D1554), the IDVP considered itself capable of expressing an opinion on the safety significance of the errors that remain undetected (IDVP Final Rep., PG&E Exh. 90, p. 6.2.5-2; Tr. D1557-59).

44. Since the nature of the undetected errors -- their location, the extent of deviation from criteria, and the conditions under which the errors may manifest themselves -- are not known, no specific analysis of them could have been done, and none has been offered in evidence.

45. Instead of providing an analysis of the safety significance of each undetected error, the IDVP relied on an assessment that, while it had not identified all of the errors, it had identified all of the "generic" errors. (IDVP Panel 1, ff. Tr. D1160, at 1/2-21, 1/2-26, 1/2-31.) But a "generic" error is merely one which the IDVP judged to have had a potential to exist in a similar manner in other, unreviewed parts of the plant. (IDVP Final Rep., PG&E Exh. 90, p. 3.5-4; Hubbard, ff. Tr. D2084, at 25.) Plainly, the likelihood of replication of an error is not determinative of its safety significance.

46. We therefore find that there is no basis for concluding that the remaining class A or B errors have no safety significance.

(2) There was no Evidence to Support the Suggestion That the Undetected Design Errors Could be Ignored in Licensing Because They Would be Detected in Preoperational Testing

47. There was some suggestion at the hearing that the existence of undetected design errors causing the design to violate the licensing criteria might be tolerated because of the likelihood the errors would be detected in preoperational testing or operation. (Tr. D1182-83.)

48. Both Mr. Anderson and Mr. Knight acknowledged that Diablo

Canyon had nearly completed its preoperational testing in 1981 when its license was suspended, and none of the subsequently discovered errors were detected in that program, nor would they have been in the remaining preoperational tests or startup. (Tr. D1271, 2718.) Mr. Anderson agreed that such testing generally cannot detect errors that would cause a failure only under emergency conditions. (Tr. D1210-12.)

49. The Board finds that the possibility of subsequent detection of design errors neither has been proven likely nor provides a valid ground for excusing compliance with all licensing criteria.

(3) Vague Claims About Overall Engineering Quality are no Substitute for Either License Compliance or an Adequate QA Program

50. PG&E offered testimony to the effect that, in the view of the witnesses, reviewers found "generally high quality engineering work." (PG&E Panel 6, ff. Tr. D1160, at 51.)

51. This claim is not material to this case. The reported results of the verification program -- specifically the indication of whether the design meets licensing criteria -- are the relevant measures of design quality. To the extent that the verification program seeks to qualify the design by showing the absence of errors, the actual results show that the design, while it may be, in the judgment of some, of high quality, plainly is not free of errors causing violations of the license.

52. To the extent that the verification program is offered as a review of the design comparable to a lawful QA program, general impressions about overall quality are even less material. The Commission has never indicated that a licensee would be relieved of its obligation to meet Appendix B by representations that spot checks of parts of the design showed those parts to be of generally high quality.

53. These requirements are even more important in this case. As Mr. Knight testified, the breakdown in QA at Diablo Canyon is unprecedented in his experience. (Tr. D2660-62.) The Board finds that assertions about overall engineering quality cannot substitute for a lawful QA program or excuse the continued presence of design errors in violation of the licensing criteria.

D. By Ignoring the Scientific Requirements for Drawing Conclusions From Sample Observations, the IDVP has Rendered its Findings About the Sampled Design Work Inapplicable to the Unsampled Portions of the Design

(1) The IDVP Violated the Commission's Requirements and its own Commitment by Failing to Avail Itself of Competent Statistical Expertise

54. The IDVP not only failed to provide a legally sufficient substitute for the missing QA program required by the regulations, it also failed to comply with the Commission Order.

55. In both its Phase I and Phase II program management plans, the IDVP committed to "arrange for an evaluation" of the entire Phase I and Phase II program "by an expert in the applicability of statistics to engineered systems." The plan for Phase II included the commitment that "the statistician retained for Phase I will be used in conducting Phase II." (PG&E Exh. 88, app. C, p. 3; PG&E Exh. 89, app. C, p. 3; Tr. D1508-12, D1514-15.)

56. The IDVP never retained a statistician for either Phase I or Phase II to review either the design or the results of the IDVP program. (Tr. D1513.)

(2) Contrary to the Claim of the IDVP, it had Never Been Relieved of the Obligations of Having the Verification Reviewed by a Competent Statistician

57. Dr. Cooper testified that he believed his commitment to

retain a statistician for the IDVP was annulled by the adoption of SECY-82-414 (PG&E Exh. 157), which contained reference to the Staff's view that "[r]igorous statistical techniques are largely inappropriate for a design verification program." (Id., encl. 11, p. 11-3; Tr. D1508.) Dr. Cooper also cited the major expansion of the sample as a ground for the IDVP no longer considering itself bound by the commitment. (Tr. D1516.)

58. In fact, the approval contained in SECY-82-414 expressly incorporated the IDVP Phase II program management plan (PG&E Exh. 89) "as modified by [a letter not in evidence and not cited by the IDVP in its testimony] and the additional requirements noted in this attachment [11] . . . ." (SECY-82-414, PG&E Exh. 157, encl. 11, p. 2 (emphasis supplied).) The program management plan, which also includes the quoted statement repeated in SECY-82-414 that the staff considers "rigorous statistical techniques . . . largely inappropriate" also contains the IDVP commitment to have the program reviewed by a statistician. (PG&E Exh. 89, app. C, pp. 1, 3.) The plan also includes "'[t]he staff['s] support [for] the use of statistical techniques in establishing the sample size'" (id., p. 1) and quotes the Staff's statement that

> "'. . . we did not think that the program plan did use statistic sampling [sic] methods to the extent that it could have, and our conclusion that whoever does this program should expand the use of sampling criteria'" as far as possible. (Id., p. 2.)

The plan also quotes the Staff's opinion that:

> "We also think these statistics can be employed in devising the sampling plan in a number of areas, that it cannot substitute for judgement in picking systems throughout, and the program plan was
>
> silent, by and large, on its use of statistics in a number of areas we think that could profit from a hard look to see to which extent questions and reliability can be examined through the design process." (Ibid.)

The plan confirms that these comments came during that portion of the Commission meeting "that served as the basis for the Commission vote to the effect that the scope and technical approach should be enlarged to include consideration of statistics in the sampling plan." (Id., p. 3.)

59. Dr. Cooper admitted that he never advised the Commission that he intended not to retain a statistician and he never received express approval for the decision. (Tr. D1519.)

60. Although the IDVP Final Report implies that the DCP retention of Dr. Kaplan was intended to fulfill the IDVP's commitment (PG&E Exh. 90, p. 3.5-8), Dr. Cooper testified that he did not so consider the hiring of Dr. Kaplan (Tr. D1514), and Dr. Kaplan did not understand himself to be serving that function (Tr. D1333). Furthermore, the arrangement between Dr. Kaplan and PG&E did not conform to the requirements of independence for IDVP contractors. (SECY-82-89, PG&E Exh. 156, p. 4; SECY-82-414, PG&E Exh. 157, p. 7; Staff Panel 1 (testim. on contention 1), ff. Tr. D2649, encl. 3 to attach. 1, p. 2; Tr. D2760-63.)

61. In fact, it was the Staff's understanding that the commitment to retain a statistician had been incorporated in the Commission's approval of the program management plan (Tr. D2761), that the commitment was still effective (Tr. D2758-59, D2763), and that the retention of Dr. Kaplan (by the ITP) constituted a discharge of that commitment (Tr. D2759, D2763).

(3) The Opinions of the IDVP, Staff, and PG&E Were Arrived at Without the Benefit of Competent Advice on the Applicability of Statistics to the IDVP

62. The opinion of the IDVP that rigorous statistical techniques were inapplicable to design verification was reached by the IDVP program manager without consulting with any person expert in the applicability of

statistics to engineered systems. (Tr. D1522, D1526.)

63. The views of the Staff concerning the inapplicability of rigorous statistical systems to design verification was arrived at by Staff members who were themselves not experts in statistics and without the benefit of the views of those members of the Staff who possess such expertise. (Tr. D2764-66.)

64. The DCP witness on statistical issues, Dr. Kaplan, was not retained by the DCP until mid-1983 (Tr. D459-61), when he was brought in "for the express purpose" of rebutting the allegations of Mr. Hubbard in an affidavit on the use of statistics (TGr. D1408-14). Dr. Kaplan does not consider himself a statistician (Tr. D1333, D1349), has no training in statistics (Tr. D1347-49), has never published in a reference journal in the field of statistics (Tr. D1348-49), and is not familiar with the literature on statistical sampling (Tr. D1329, D1363-66).

65. The Board finds that the applicant and Staff have failed to show by competent evidence that statistical techniques are inapplicable to design verification.

(4) Statistically Valid Random Sampling is Essential to Generalization From Sample Observations to the Unsampled Portions of the Population

66. Both Prof. Apostolakis and Prof. Samaniego testified that random sampling is essential to a valid generalization to a population. (Apostolakis, ff. Tr. D2313, at 15, 19; Samaniego, ff. Tr. D2392, at 5, 7, 8; Tr. D2353-54, D2394-95, D2399-D2401, D2425-26, D2430-33, D2514-22.) Random sampling is not an essential of all scientific inquiry, but it is an essential of any generalization of probabilities from samples to populations. (Tr. D2430-33.)

67. The use of random sampling is no less a requirement of Bayesian statistics as it is of classical statistics (Tr. D2343), and the use of a non-random sample to update a prior using Bayes Theorem is "simply wrong," "inappropriate," and "completely invalid." (Tr. D2394-95.)

68. The Board finds that random sampling is a requirement of any valid generalization of observations from sample data to the unsampled portions of a population.

(5) It is Possible to Conduct a Statistically Valid Design Verification Program

69. Prof. Apostolakis testified that one can employ statistics in a design verification program. (Apostolakis, ff. Tr. D2313, at 13-14.) And Dr. Kaplan described his own testimony as demonstrating that one can derive error rates from a sample of the design of a nuclear power plant using "statistics-like" techniques. (Tr. D1163.)

70. Although Prof. Apostolakis confirmed that one could set up the random sampling problem in such a way that it would be extremely large and extensive, such as by sampling from the population of all design decisions (Tr. D2340), he also was of the opinion that the problem could be structured in such a fashion as to make it manageable (Tr. D2341) and that the question of how one characterizes the population is distinct from the question of whether one randomly samples from the population (Tr. D2353).

71. None of the reasons given by Dr. Kaplan why he considers "classical statistics" inapplicable to design verification is valid:

(a) There is, as Dr. Kaplan testified, a need for a well-defined set of elements. (PG&E Panel 6, ff. Tr. D1160, at 5.) But he demonstrated that such a set could be developed. (Tr. D1163.)

(b) Although Dr. Kaplan asserted that the elements must all be equal and

well mixed, he acknowledged that one could validly take a random sample of a heterogenous population or one could stratify the population and take random samples within strata. (Tr. D1272-97.)

(c) Dr. Kaplan testified that the elements of the population must be readily identifiable in terms of the attribute (PG&E Panel 6, ff. Tr. 1160, at 5) -- in the context of design verification, one must be able readily to identify an element as either containing an error or not (Tr. D1279). But he acknowledged that this is not a problem of statistics, but a problem of design verification, which beset the IDVP fully as much as it would one performing a statistical study. (Tr. D1279-890.) And, indeed, the definitions used in Dr. Kaplan's own testimony for significant errors were, he acknowledged, "at least as fuzzy" as the definitions used by the IDVP. (Tr. D1280.)

(d) Dr. Kaplan stated that classical statistics focuses on frequencies, which he considers a limitation on its applicability to design verification. (PG&E Panel 6, ff. Tr. 1160, at 5.) But both Prof. Apostolakis and Prof. Samaniego testified that the issue of random sampling is independent of the Bayesian versus classical statistics debate -- that both Bayesians and classical statisticians use random sampling. (Tr. D2343-44, D2394-95, D2404.)

(e) Dr. Kaplan cited the "interconnected nature of design" as a reason why statistics was inapplicable. (PG&E Panel 6, ff. Tr. D1160, at 6, 42-43; Tr. D1288.) But Mr. Anderson agreed that if one were interested in capturing this integrative quality, one could, with a detailed review of all the systems, enumerate all of the integrative aspects, and Dr. Kaplan agreed one could then sample randomly from that list to

study whether there were errors in the way those relationships were treated in the design. (Tr. D1289.) Prof. Samaniego testified to the same effect. (Tr. D2405-07.)

(f) At the heart of Dr. Kaplan's objections to the use of statistics was his view that statistics failed to make adequate use of non-frequency information -- particularly the opinions of experts. (PG&E Panel 6, ff. Tr. D1160, at 11-12, 15-16, 42, 54, 68-69; Tr. D1286.) Dr. Kaplan and Prof. Samaniego, however, agreed that expert opinion can be incorporated into the statistical framework by stratifying the population according to the experts' advice. (Tr. D1304, D2404-05.)

72. In the final analysis, the Board finds that the issue is not between classical and Bayesian statistics, but between sampling in accordance with statistical principles -- a requirement of both Bayesian and classical statistics -- and sampling non-randomly, a practice that the evidence shows to be invalid to adherents of both schools. The Board finds that no valid reason has been given why one cannot employ statistically valid sampling techniques in a design verification program.

(6) Proper Sampling is not Only a Legal and Scientific Requirement, but Plainly Necessary to the Objectives of the Verification Program

73. That sampling for a verification program be done on a random basis from the work of each design group is an obvious requirement of any effort to provide assurance of an error-free design.

74. Dr. Kaplan testified that different design contractors will vary in their error rates. (Tr. D1309.) Thus, sampling from the work of one contractor provides no reliable information about the likelihood of errors in the work of some other, unsampled, contractor.

75. Likewise, changes in the composition of a design team can be expected to alter the likelihood and distribution of errors. (Tr. D1309.) In the 15 years during which the Diablo Canyon design was evolving, the PG&E design teams experienced the expectable personnel changes. (Tr. D1309-10.)

76. The Board therefore finds that a verification program that fails to employ statistically valid sampling techniques and that fails to sample from the work of all design groups cannot provide the requisite assurance that the design complies with licensing requirements.

E. The IDVP has not Verified the Design of Unit 2

77. The scope of the IDVP was limited to Unit 1. (Commission Order, PG&E Exh. 86; Staff Letter, PG&E Exh. 87; IDVP Final Rep., PG&E Exh. 90, p. 1.1-1.)

78. The IDVP did not review the design of Unit 2. (IDVP Panel 1, ff. Tr. D1458, at 1/2-35 - 1/2-36.)

79. While there are many similarities in the designs of Units 1 and 2 (PG&E Panel 1, ff. Tr. D224, at 28-29), the two units are generally mirror images of one another and not identical (Tr. D2274). Among the differences are different reactor internals, differences in thermal output, resulting in differences in accident analyses, differences in the design of the electrical generator, and differences in equipment vendors. (PG&E Panel 1, ff. Tr. D224, at 29-29.) Although the piping and instrumentation schematics are identical (ibid.), those merely show functional relationships and not physical relationships (Tr. D2775).

80. PG&E witnesses testified that the two units were originally designed to the same design criteria (PG&E Panel 1, ff. Tr. D224, at 29), but they did not claim that the designs themselves were identical. In

fact, a substantial amount of design work unique to Unit 2 has been done and will be done, with PG&E having, at peak some 400 to 500 engineers working exclusively on Unit 2. (Tr. D1319.) Both PG&E and Staff witnesses acknowledged the fact that there are opportunities for design errors in Unit 2 that would be unique to that unit. (Tr. D1321-22, 2776.)

81. Mr. Schierling testified that he expects the Staff to issue a separate supplement to the SER to cover Unit 2. (Tr. D2778-79.)

82. Until recently, the two units were designed by a single design organization under a common QA program. (PG&E Panel 1, ff. Tr. D224, at 29; Tr. D2772.) Some of the design work for Unit 2 was done before November 1981 (Tr. D1320), under the program the IDVP and Staff found to be significantly deficient (Tr. D2772).

83. In the opinion of Prof. Apostolakis, the IDVP does not provide a valid basis for assessing the design quality of Unit 2. (Apostolakis, ff. Tr. D2313, at 20.)

84. The Board finds that the IDVP has neither proven the design of Unit 2 to be free of errors violation licensing criteria nor subjected Unit 2 to scrutiny comparable to that of a lawful QA program.

II.

THE ITP DOES NOT PROVIDE THE ASSURANCE MISSING FROM THE IDVP THAT THE DESIGN OF DIABLO CANYON MEETS THE LICENSE CRITERIA AND APPLICABLE REGULATORY REQUIREMENTS

85. Although we have found that the IDVP satisfies neither requirement we have established for a substitute for a legally sufficient QA program, our inquiry is not over. It remains for the Board still to determine whether the ITP can meet either test for a verification program: the demonstration of a design free of errors causing violations of license

criteria or the review of the design comparable to that provided by an adequate QA program.

86. We have already found that the verification program has demonstrated the virtual certainty of remaining class A and B errors. While that does not prevent the ITP (or the IDVP) from trying to prove that specified portions of the design are error-free, PG&E has sought to make no such showing. Rather, it has focused on the question of safety significance, which we have already rejected as the appropriate criterion for the present licensing decision.

87. The remaining question, therefore, is whether the ITP has subjected the design to the same level of scrutiny it would have received from an adequate QA program.

A. The ITP's Seismic Verification Program Provides Only a Limited Substitute for a Lawful QA Program

88. The ITP's review of the seismic design of Unit 1 -- which is referred to as the Phase I program, as distinguished from the Phase II program for the non-seismic design -- consisted of a more extensive review than its review of the non-seismic design. However, it did not comprise a 100 percent review of all elements of the seismic design. The Phase I Final Report makes it clear that many systems and components were reviewed only on a sampling basis, others only on a "generic" basis, and others only for the presence of a single error or a predetermined list of errors.

89. The PG&E Phase I Final Report states that the following systems and components received a seismic review only on a sampling basis, not a 100 percent review basis:

-- Small bore piping: The DCP used unspecified sampling techniques to select a sample of all small bore piping for review of certain

potential design errors; twenty pipelines were addressed out of an unspecified number plantwide (PG&E Phase I Final Rep., PG&E Exh. 91, § 2.2.2.3.3.) This was done in adition to the "generic" review discussed, infra.

-- Instrument tubing supports: A "representative" (undefined) sample of 88 tubing supports was reviewed solely to determine whether the supports were affected by revisions to response spectra. This sample was limited to the portions of the annulus affected by the changed spectra. (PG&E Phase I Final Rep., PG&E Exh. 91, § 2.6.1.)

90. The following systems and components were reviewed by PG&E for only selected and predetermined potential design errors, and for no other possible design errors:

-- Equipment in general received an initial review solely to determine if the applicable response spectra had changed. If spectra did not change, no further review was done. (PG&E Phase I Final Rep., PG&E Exh. 91, § 2.3.1.3.)

-- Specifically, electrical equipment was reviewed solely for changes in applicable spectra. Only if spectra changed was any further design review done. (Ibid., §§ 2.3.2.3.2 & 2.3.2.3.4.)

-- HVAC equipment received a spectra change review, with no further review undertaken unless spectra had changed. (Ibid., § 2.3.3.2.)

-- Instrument tubing and tubing supports: The sample of 88 tubing supports discussed, supra, was reviewed only to determine if spectra had changed, and received no further review if they had not. (Ibid., § 2.6.1.)

91. One set of components was reviewed by PG&E on a "generic" basis, reviewed for a specific list of factors predetermined by the ITP or

the IDVP as potential causes or areas of design errors:

-- Small bore piping: In addition to the sampling review for certain types or potential design errors, a so-called generic review was done for specific problem areas identified by ITP and IDVP reviews.

92. Finally, the following systems and components were systematically excluded by PG&E from review:

-- Large bore piping analyzed by Westinghouse: This piping was not reviewed by PG&E. Where data input changed, the revisions were supplied by PG&E to Westinghouse, but no review was done by PG&E of the analysis. (Ibid., § 2.2.1.1.)

-- Equipment: Only equipment associated with safety systems designed by PG&E was reviewed by the ITP. No other equipment was reviewed. (Ibid., § 2.3.)

93. The Board finds that the seismic review consisted of a partial verification of some SS&Cs against some criteria.

B. The ITP's Non-Seismic Verification Provides no Basis for Drawing Conclusions About Those Portions of the Design not Sampled by the IDVP

(1) Prior to the Hearing, the ITP's Phase II Program was not Represented as an Independent Verification Effort

94. The Phase II Final Report (PG&E Exh. 92) describes the function of its Phase II ITP in terms of furnishing information to the IDVP, managing records and information, and "normal support activities." (Id. at 1-5.)

95. Nowhere in the DCP Phase II Final Report is there any description of an ITP verification program beyond the scope of the IDVP.

(2) At the Hearing PG&E Sought to Recharacterize the ITP as a Verification Program of Larger Scope Than the IDVP

96. In its direct testimony at the hearing, PG&E Panel 1, for

the first time, sought to characterize the ITP Phase II review as a "self-contained and separate review" (PG&E Panel 1, ff. Tr. D224, at 13), though not a "complete review" nor a "total review" (id., at 16, 20). The panel offered no quantitative measure of how much of the non-seismic design work the ITP had reviewed. Similarly, PG&E Panel 6, which presented detailed figures on the fraction of the non-seismic design verified by the IDVP, made only passing reference to the verification by the ITP, admitting it did "not attempt to quantify it" (PG&E Panel 6, ff. Tr. D1160, at 64).

97. For the first time on redirect, PG&E Panel 6 was asked to provide a quantitative description of the scope of the "separate" ITP Phase II review. Mr. Anderson opined that the ITP reviewed "somewhere between 45 and 50 percent" of the non-seismic "engineering work" (Tr. D1419), which he added was "over and above" his estimate of 30 percent of the engineering work he claimed the IDVP had verified (ibid.). This led him to the opinion --expressed for the first time by any PG&E witness. On redirect on the sixth and final day of PG&E's case-in-chief -- that between 75 and 80 percent of the non-seismic design had been verified by either the IDVP or the ITP (Tr. D1419-20), well over half of that by the ITP alone.

(3) The ITP did not Conduct a Verification Program Independent of the IDVP

98. Conspicuously missing from the documentation of the ITP is any of the information one would expect to see reported on a verification program -- information that is reported for the IDVP seismic and non-seismic verification and for the DCP Phase I program. There is no enumeration of the systems and components reviewed, nor even of the number of such systems and components; there is no identification of the criteria against which the design of each was verified; there is no discussion of

who did the review; there is no report of the number of errors of each class -- A, B, C, and D -- detected.

99. The IDVP Final Report (PG&E Exh. 90) does refer to "an additional design verification effort to assure the overall adequacy and design of the plant" as one purpose of the DCP (id., at 1.4-2), but the report goes on to describe the DCP's Phase II program thusly:

> "The DCP Phase II activity is issue-oriented, responding on a case-by-case basis to specific non-seismic concerns identified by the IDVP and to results of internal DCP activities.
>
> "Although the DCP is taking corrective action with respect to specific concerns, the DCP efforts were not intended to be a comprehensive program equivalent to that performed for Phase I." (Id., at 1.4-4 - 1.4-5.)

100. Mr. Anderson testified that this "review" was "not nearly as systematic as the IDVP's review" (Tr. D1426), and not documented as a review process at all (ibid.). Instead, this "review" was really just a by-product of "putting the files . . . and . . . the paperwork in order." (Tr. D1427.) He admitted that this ITP review was "not of the same depth" as the IDVP. (Tr. D1426, D1427, D1428, D1429.) Unlike the IDVP, ". . . where they were looking at a system in its totality, all of the requirements, all of the commitments," (Tr. D1427) looking at three systems in a "very in-depth review, [w]e did not spend that much time on three systems." (Tr. D1428.) "We just didn't look at it, at the systems as thoroughly as they did." (Tr. D1429.) "I just don't think we looked at all of the details to the extent that they did." (Ibid.)

101. The lesser scrutiny the ITP gave the design in its review is evidenced by its results. In its review, the IDVP found nine class A or B errors in what Mr. Anderson characterizes as 30 percent of the design work.

(PG&E Panel 6, ff. Tr. D1160, at 48.) In reviewing a slice of the design Mr. Anderson characterizes as being 50 percent larger than the IDVP sample (45 percent to 50 percent versus 30 percent), the ITP found only seven "open items." (Id., at 64.) So the ITP found substantially fewer design errors than the IDVP in a substantially larger sample than the IDVP's sample. Since the IDVP disclaimed having selected its sample for a higher-than-average error rate (Tr. D1549), there is no basis to conclude that the ITP found fewer errors than the IDVP because there were fewer to be found. The most reasonable inference is that the ITP found fewer errors than the IDVP because its review was less likely to find them, the natural consequence of what Mr. Anderson characterized as the lesser depth of the ITP's review.

102. Accordingly, the Board finds that the ITP's review of the non-seismic design is not functionally equivalent to the verification performed by the IDVP and not an adequate substitute for the absent QA program.

(3) There is no Substantial Evidence to Support PG&E's Claim That the ITP Reviewed 45 Percent to 50 Percent of the Non-Seismic Design, Nor to Support the Claim That the IDVP and the ITP Together reviewed 75 to 80 Percent

103. In his redirect testimony at the hearing, Mr. Anderson estimated that the IDVP reviewed 30 percent of the non-seismic engineering work. (Tr. D1419.) The direct testimony of PG&E Panel 6 indicated the IDVP sample consisted of 911 of the 3968 "design elements" comprising the non-seismic design work -- less than 23 percent. (PG&E Panel 1, ff. Tr. D1169, at 48.) Mr. Anderson offered no basis for estimating that the 23 percent of the "design elements" amounted to 30 percent of the "engineering work." (Tr. D1436-38.)

104. Nor does Mr. Anderson offer any reliable basis for his estimate that the DCP reviewed 45 percent to 50 percent of the "engineering

work." He admitted at the hearing that at his deposition he had estimated the IDVP and ITP sampled together (Tr. D1430, D1433) at 50 percent or above -- leaving the ITP sample around 20 percent according to his figures. (Tr. D1426-30.) He explained his doubling of his estimate of the ITP's sample on the basis of having given the matter "further review." (Tr. D1430, D1431, D1434.) Mr. Anderson could give no grounds for the estimate other than his "judgment." (Tr. D1440.) Dr. Kaplan's effort to "salvage" the quantitative claim (Tr. D1423) consisted of a reference to the shading in the diagram in the prepared testimony (PG&E Panel 6, ff. Tr. D1160, at 66) -- although he had previously admitted that the diagram does not show the fraction of the design work the IDVP actually sampled (TR. D1323).

105. Mr. Anderson also testified that the 30 percent he estimated the IDVP verified and the 45 percent to 50 percent he thought the ITP reviewed could be added together for a 75 percent to 80 percent of the non-seismic design reviewed by the verification program. (Tr. D1420.) But on cross-examination, he acknowledged that there is some overlap between the 30 percent he attributes to the IDVP and the 45 percent he assigns to the ITP (Tr. D1430), so that simply adding the two figures together as he had would not "in a strict sense" be correct (Tr. D1431). Yet Mr. Anderson maintained that the 75 percent to 80 percent figure was still correct. (Tr. D1431.)

106. Mr. Anderson admitted on cross-examination that his numbers estimating the fraction of the non-seismic design examined by the verification program were "rather soft." The Board agrees and finds that the evidence does not support any conclusion about the actual fraction of the design reviewed by the ITP or the combined verification program.

C. The Probabilistic Calculations Presented by PG&E Panel 6 does not Constitute Reliable Evidence on Any Material Issue Before This Board

107. Dr. Kaplan presented a probabilistic analysis, purporting to employ the opinions of the DCP and the results of the IDVP's non-seismic design verification to calculate, using Bayes' Theorem, the likelihood of there remaining an undetected safety-significant error in the design of Unit 1. (PG&E Panel 6, ff. Tr. D1160, at 53-63.) For the reasons given below, the Board finds the analysis unreliable and irrelevant to the licensing of Diablo Canyon:

(1) The analysis focuses on the likelihood of a safety-significant error, rather than violation of the licensing criteria. Since the Board has found that to be the wrong question, the answer is irrelevant.

(2) The analysis does little more than restate the opinions of the DCP, which dominate the probabiistic results. In applying Bayes' Theorem to the verification problem as he characterized it, Dr. Kaplan consulted with the DCP about their opinions on the likelihood of a safety-significant error, instructing them to disregard the information obtained from the sample. (PG&E Panel 6, ff. Tr. D1160, at 56-56; Tr. D1219-24.) This quantity, which is called the "prior distribution" (i.e., prior to the addition of other evidence), was .001--in other words the DCP was 99.9 percent sure there were no safety-significant errors even without reference to the IDVP results. (Id., at 57.) When he then employed Bayes' Theorem to combine the IDVP results with the prior distribution, he obtained a "posterior" probability of there remaining a safety-significant error in Unit 1 of .00003. (Id., at 63.) Plainly, the results of the analysis are dominated by the DCP's assump-

tions. Dr. Kaplan goes from a prior he elsewhere describes as "essentially certain beforehand" that there is no safety-significant error (Tr. D1388) to a probability only slightly smaller. Prof. Apostolakis showed that a different prior distribution, which he thought a reasonable person might have had in late 1981 (Tr. D2319-20), when subjected to the Kaplan analysis with no other modifications would yield a posterior probability of at least one safety-significant error of 5 percent (Tr. D1260-61, D1268-70)--more than a thousand-fold increase.

(3) The analysis relies on inherently suspect opinion evidence. Prof. Apostolakis testified that there exists a body of evidence that people in general tend to have great difficulty assessing probabilities, "to deny uncertainty, misjudge risks, and express unwarranted confidence in their judgments." (Apostolakis, ff. Tr. D2313, at 6.) The literature also shows people have special difficulty dealing with rare events. (Id., at 7.) He also cited studies -- including one he co-authored with Dr. Kaplan showing that experts tend to underestimate risks. (Id., at 6-7.) This evidence underscores the weakness of an analysis that relies on opinion evidence that is too unreliable to serve as the basis for a licensing decision.

(4) The results of the probabilistic calculations are based on a non-random sample and therefore invalid. PG&E and the IDVP agreed that the IDVP sample was not randomly drawn. (PG&E Panel 6, ff. Tr. D1160, at 41-42; IDVP Panel 1, ff. Tr. D1458, at 33-34.) Both Prof. Apostolakis and Prof. Samaniego testified that random sampling was essential to drawing valid inferences. (Apostolakis, ff. Tr. D2313, at 15; Samaniego, ff. Tr. D2392, at 5.) Prof. Samaniego stated the proposition most strongly:

that the absence of random sampling rendered Dr. Kaplan's use of Bayes' Theorem "wrong," "inappropriate," and "completely invalid." (Tr. D2394-95.) PG&E neither recalled Dr. Kaplan or otherwise sought to rehabilitate his testimony. The Board therefore finds that the quantitative results presented by Dr. Kaplan must be disregarded.

D. To Complete Verification of Diablo Canyon, PG&E Must Establish for Each Portion of the Design Either That it is Free of Class A or B Design Errors or That it has Been Subjected to the Same Scrutiny it Would Have Received for Under a Legally Adequate QA Program

108. From the foregoing follows what PG&E must do to meet the requirements of a verification program and to qualify the design of Diablo Canyon Units 1 and 2 under the Commission's regulations:

(1) For those portions of the design we have found above to have already been verified, no further review of the verified design is required.

(2) For those portions of the design that we have not found PG&E to have demonstrated verification, but where PG&E believes it can provide documents sufficient to meet the standards for a verification program we have established here, PG&E may use existing documentation to demonstrate the design has been verified.

(3) For the remaining portions of the design, PG&E retains the option for each such portion of either (a) demonstrating in a statistically valid manner that there the design is free of class A or B errors or (b) subjecting that portion of the design to a 100 percent review.

The Board finds that until PG&E has done so, the Commission cannot have the necessary confidence that the design meets the licensing criteria and regulatory standards. The Board further finds that once PG&E has completed this task, it will have satisfied the requirements of a verification

program, overcome the past shortcomings of its design QA program, and qualified the design of the facility.

III

THE SEISMIC VERIFICATION PERFORMED BY THE ITP AND THE IDVP IS DEFICIENT IN THAT IT DOES NOT DEMONSTRATE THE SEISMIC QUALIFICATION OF ALL STRUCTURES

A. PG&E Used Incorrect Methods to Model Soil Structure Interaction for Containment

109. As part of its modeling of the seismic response of the containment building, the DCP included an analysis of the interaction of the behavior of the underlying foundational material (the rock underlying containment) during the appropriate earthquakes, and the effects of that behavior on the seismic response of the containment building. This is known as a soil structure interaction analysis. In that soil structure interaction analysis for containment, the DCP used an axisymmetric soil mass representation, a model that represent the foundational material as a cylinder. (Tr.D655.)

110. In performing the soil structure interaction analysis, the DCP applied the same earthquake motion input to both the side and bottom boundaries of the soil mass model, a procedure inconsistent with current soil structure interaction modeling. (Tr. D655, D656, D2294-98). This boundary motion input procedure produces motion at the free surface that varies from each edge to the center of the soil mass. This also is not consistent with current methods of soil structure interaction analysis. (Tr. D661.)

111. Finally, the DCP applied a correction factor to the model to offset the discrepancies in free surface motion from the true design spectra caused by its method of inputting the same earthquake motion at both bottom and side boundaries of the soil mass. Use of such correction factor is not

consistent with current practice. (Tr. D659-60.)

112. However, and largely due to the fact that the soil mass under containment is hard rock, the correction factor used by the DCP has produced results sufficiently conservative to be acceptable. (Tr. D2638-39.)

B. PG&E Has Modeled the Soil Springs Under the Auxiliary Building Inconsistently, and Has Failed to Take Into Account All Effects That the Springs May Cause

(1) The DCP Has Not Considered a Fixed Base Analysis

113. PG&E modeled the soil mass under the auxiliary building by assuming a fixed base (i.e., very stiff or rigid foundational material under the structure) at elevation 85 feet, and soil springs (a way of representing less stiff, more flexible soil or rock) at elevation 100 feet. Expert testimony and exhibits dealing with the value of the soil represented by the soil springs used to represent the soil under the auxiliary building at elevation 100 feet varied widely. Estimates ranged from 3500 feet per second shear wave velocity by the IDVP in one ITR (IDVP, "Best Estimate," Table 7, ITR 55, PG&E Exh. No. 145), to 2700 feet per second by PG&E (Tr. D701), to 2500-2700 feet per second by the Staff (Tr. D2515), to approximately 1500 feet per second by the IDVP in a second ITR (based on conversion of compressional wave data in Figure 15 of ITR 68 to shear wave data; see Tr. D2226).

114. The DCP used a fixed base soil structure interaction analysis for the auxiliary building at elevation 85 feet for all earthquakes. The IDVP concurred with this approach, noting that the Hosgri report provides for a fixed base analysis for foundational material of 3500 feet per second shear wave velocity (ITR 55, PG&E Exh. 145, p. 19), a value that indicates very stiff rock. The IDVP felt that the approach was justified for the DE

and the DDE because of the stiffness of the rock (ITR 55, page 32).

115. However, no fixed base soil structure interaction analysis was performed for the auxiliary building at elevation 100 feet, despite the IDVP's estimate of the foundational material at that elevation as 3500 feet per second shear wave velocity, the same shear wave velocity used to justify the use of a fixed base analysis at 85 feet for all earthquakes.

116. No justification was presented for use of the fixed base analysis at elevation 85 feet and lack of such fixed base analysis at elevation 100 feet (Tr. D700), despite the fact that IDVP estimated shear wave velocity of the rock at both elevations as being 3500 feet per second or higher.

117. An increase in the forces in the shear walls of the auxiliary building could occur if the foundational material at elevation 100 feet were not assumed to be flexible, as would be the case in a fixed base analysis. (Roesset, ff. Tr. D2206.) All analyses have assumed flexibility in the soil at elevation 100 feet (ITR 55, PG&E Exh. 145, Table 5). The results of Table 5 in ITR 55 seem to indicate that the base shear force increases with increasing stiffness of the springs, and then decreases again. (ITR 55, PG&E Exh. 145, Table 5.) It has not been shown, however, that the base shear would continue to decrease with a fixed base. No showing has been made by the DCP that the shear walls are qualified for any increase in forces that might come from a fixed base, other than by citing the possibility of inelastic deformation not provided for in the licensing criteria. (Tr. D713-15.)

(2) The DCP Has Not Considered Rotational Effects of Flexible Soil Springs

118. The analysis of the auxiliary building has not accounted for all effects that might occur if the foundational material represented by soil

springs is as stiff as the IDVP estimate of 3500 feet per second shear wave velocity, as discussed above. It is also the case that the DCP has not considered all effects that could occur if the soil springs are as soft as the low estimate implied by Figure 15 of ITR 68. (PG&E Exhibit 155.)

119. Variation in the stiffness of the soil of the magnitude described above can produce variations in the seismic response of the auxiliary building. ITR 55, PG&E Exhibit 145, page 25, states that a 20% increase in response spectra acceleration would occur over the values of the soil springs considered by the IDVP in its parametric study of soil spring values. This 20% increase in response spectra calculated by the IDVP was based on a lower bound for the value of the soil springs of 2000 feet per second shear wave velocity. ITR 55 notes that that much of an increase is acceptable to the IDVP specifically because this lower bound value is conservative (ITR 55, page 25). Although the IDVP testified that the soil springs did not have much effect (IDVP Panel 2, ff Tr. D1843 at 3-9), the IDVP parametric studies showed a large variation in the seismic response of the base at elevation 85 feet of the Auxiliary Building with variation of the soil spring values (Tr. D2470-71, D2220).

120. A building with a foundation that is both embedded and at differing elevations, as is the auxiliary building, will experience varying earthquake motions at the more deeply and at the more shallowly embedded portions of foundation, respectively. (Tr. D2524.) This variance in motion experienced by the different portions of the base could produce a rocking motion, which would vary with the stiffness of the soil. (Roesset, ff. Tr. D2206, at 11; Tr. D2526.)

121. The IDVP parametric studies did not address the effects on the

seismic response of the auxiliary building of considering the soil springs to have a value of 1500 feet per second shear wave velocity, as Figure 15 of ITR 68 implies (see Finding 113, supra). Material of this value would be hard soil rather than rock, and would be softer than the lowest value of soil spring material considered by IDVP. (ITR 55, PG&E Exh. 145, Table 5; Tr. D2226.) Testimony of the NRC indicated that any rocking motions of the auxiliary building referred to in Finding 120, supra, would be increased by such softer soil. (Tr. D2526.)

122. Despite the possibility that flexible soil springs could produce rocking motions of the structure, that could be increased by an assumption that the soil springs are softer than the IDVP assumed in its parametric studies, no analysis has been done by PG&E or the IDVP of the effects on the seismic response of the auxiliary building of rotational effects.

123. A fixed base analysis of the soil structure interaction for elevation 100 feet of the auxiliary building, would be consistent with the fixed base analysis done for elevation 85 feet, if the shear wave velocity of the foundational material at both elevations is 3500 feet per second. The DCP has failed to perform such a consistent analysis, or to qualify the auxiliary building for any effects predicted by such an analysis.

124. The DCP has assumed soil springs of a different shear wave velocity at elevation 100 feet than at elevation 85 feet. However, the Board finds that the DCP has failed to do an analysis for all credible values of the soil springs, and has failed to qualify the auxiliary building for all effects, including rocking motions, that such soil springs could cause.

C. The DCP Has Failed to Qualify All Equipment in Containment For the Anticipated Effects of an Uplifting of the Containment Base Mat

125. General Design Criterion 2 of Appendix A to 10 C.F.R., Part 50,

requires that all structures, systems, and components important to safety be designed to withstand the effects of natural phenomena, such as earthquakes. In addition, licensing criteria specify maximum allowable stresses for which various systems, structures, and components are qualified and to which they may be subjected.

126. Expert testimony by Dr. Roesset established that the containment base mat, the large concrete slab that is the foundation of the building, might separate from the rock beneath containment and lift up if the containment experienced accelerations over 0.4g, well under Hosgri accelerations. (Roesset, ff. Tr. D2206, at 8.) All parties testified that uplift might occur at Hosgri accelerations (0.67g). (Roesset, id.; Tr. D675; D2507-10; D1888; D1875; D1876; D1954-55.)

127. Such an uplifting of the containment base mat would cause a change in the center point of contact (the centroid) between the base mat and the underlying rock (Roesset, ff. Tr. D2206 at 6-7), producing a shift in the axis of rotation (Tr. D2213-14), and increased vertical accelerations not accounted for in the DCP analysis of containment (Tr. D1881, D2215-16), as the building rises from the ground very slightly at one edge. The increased vertical accelerations from uplift could cause increased vertical stresses on equipment in containment. Such increases could be on the order of 10-15%, but could be especially significant for equipment whose qualification is controlled by the vertical component (Tr. D2216; Tr. D2214-15; Tr. D2510).

128. No analysis has been done by the DCP or the IDVP of the effect on any equipment inside containment of increased vertical acceleration due to uplift (Tr. D828).

129. The testimony clearly established that uplift of the containment base mat may occur at Hosgri accelerations, and may occur at lower accelerations. All parties agreed that uplift could cause increased accelerational in the vertical direction on the equipment in containment, and that no one has done any analysis to determine whether all or any equipment in containment is qualified for such accelerations. Thus, the Board finds that the DCP has failed to qualify all safety-related equipment for possible effects of earthquakes, in violation of General Design Criterion 2.

D. The DCP's Use of Translational and Torsional Inputs to the Fuel Handling Building Has Not Been Shown to be Valid

130. Contention 3(o) challenged the validity of certain aspects of the DCP's modeling of the fuel handling building, particularly how the DCP used the motion of the auxiliary building to determine the motion to input to its model of the fuel handling building. No findings are yet possible regarding the validity of the DCP's use of translational and torsional inputs to the fuel handling building, since no written analysis confirming the DCP use of input to the base of the columns has yet been submitted to the parties or the Board. The Staff has been given information orally, which it feels would be adequate if confirmed, but has not had confirming and verifiable written substantiation. (Tr. D2528-30.)

E. No Consistent, Documented Representation of the Properties of the Soil and Rock Surrounding the Diesel Fuel Oil Tanks Has Been Produced by the DCP or the IDVP

(1) The data used to determine soil properties was determined without a QA program, and tests have not been redone by the DCP or the IDVP

131. The testimony of PG&E, the IDVP, and the NRC regarding soils properties of the backfill surrounding the diesel fuel oil tanks was all based on the work of Harding Lawson Associates. (ITR 68, PG&E Exh. 155, page 1;

NRC Panel 2, ff. Tr. D2463, at 24; Tr. D763.) The IDVP performed a quality assurance review of Harding Lawson Associates, and found that it implemented no quality assurance program for the Diablo Canyon soils work. (ITR 68, PG&E Exh. 155, p. 2.) PG&E has not reperformed any field tests, laboratory tests, or sampling done by Harding Lawson Associates. Also, it has not verified this work except by a general review for reasonableness of results. That review appears to have been done by only one or two persons, and it is not clear if any of this review was documented. The testimony seems to indicate it was not. (Tr. D767; D773; D775; D798.) Though, the IDVP reviewed the geologist's log and the data for reasonableness of results, and compared data to the literature, it performed no physical tests. (ITR 68, PG&E Exh. 155, pp. 4-5.)

(2) ITR 68 presents contradictory information about the backfill around the diesel oil fuel tanks

132. In Figure 14 of ITR 68 (PG&E Exh. 155), contradictory information is presented as to the soil properties of the soil surrounding the diesel fuel oil tanks. The same soil is represented by a shear modulus versus mean effective stress curve with an exponent of 0.18, and by a curve with an exponent of 0.7. These exponents differ by a factor of more than three, and this difference implies a large uncertainty in representation of the soil properties. (Roesset, ff. Tr. 2206, at 18; Tr. D2539.) Examination of each of these exponents reveals more uncertainty as to soil properties. Figure 14 of ITR 68 purports to describe soil that is sandy clay (Tr. D771). However, the exponent of 0.18 is very low for a sandy clay (Roesset, ff. 2206 at 18; Tr. D2537), and the exponent 0.7 is very high, being closer to a sand (Roesset, ff. Tr. D2206, at 18; Tr. D2538; Tr.

D779). The ITR does not make clear either the nature or the properties of this backfill soil.

(3) ITR 68 presents information about the rock around the diesel fuel oil tanks that contradicts data used to qualify the auxiliary building

133. The diesel fuel oil tanks are near the auxiliary building, and the material surrounding them is very near or beneath that building. (ITR 68, PG&E Exh. 155, Figure 5, p. 71.)

134. ITR 68, Figure 15, presents compressional wave data which, when converted to shear wave velocities, show a shear wave velocity for the rock around the tanks and around the auxiliary building at 100 feet of about 1500 feet per second (Tr. D2227), a value for which no soil spring analysis has been performed (Finding 122, supra). Strains associated with a Hosgri event might reduce the shear wave velocity of the rock around the auxiliary building to 1000 feet per second or less (Tr. D2227), based on extrapolations from the data in Figure 15 of ITR 68. No analysis has been performed for rock of this value (ITR 55, PG&E Exh. 145.)

135. NRC and IDVP witnesses testified for the first time under cross-examination that the data in ITR 68, Figure 15, should be disregarded as "less reliable" for calculating the shear wave values of the rock around the auxiliary building than other data gathered from up-hole and cross-hole tests performed by Harding and Lawson in 1967 and 1973. (Tr. D2548; Tr. D3122; Tr. D3112.) The IDVP witness, Dr. Cloud, offered as his only reasons for discounting the data in Figure 15 of ITR 68, his judgment that the test method used to gather the data in Figure 15 is less reliable by some unquantified margin at this site than the up-hole and cross-hole tests whose results were relied on in qualifying the auxiliary building. (Tr.

D3112; D3125; D2010-11.) No other evidence was adduced that the data in Figure 15 were not correct.

136. The cross-hole and up-hole data regarded by the IDVP as of greater reliability than the data in Figure 15 of ITR 68 were gathered by Harding Lawson Associates (Tr. D3125; D3137) during the period of time for which they had no QA program. (ITR 68, PG&E Exh. 155, p. 2.)

137. The Board finds that the data in ITR 68 and the testimony revealed pervasive inconsistencies in the properties claimed for the backfill soil around the diesel fuel oil tanks. No conclusions as to the properties of that soil can be drawn, based on the conflicting and internally inconsistent evidence before the Board.

138. The evidence also revealed that no consistent, well-documented representation of the properties of the rock surrounding the diesel fuel oil tanks and underlying the auxiliary building at elevation 100 feet. Upon the evidence before the Board, it is not possible to find that the soil spring values used in the seismic analysis of the auxiliary building are correct, nor is a finding possible as to what the properties of the rock surrounding the diesel fuel oil tanks are.

F. No Consistent, Documented Representation of the Properties of the Soil Surrounding the Auxiliary Saltwater Piping and Circulating Water Intake Conduits Has Been Presented by the DCP or the IDVP

(1) The data used to determine soil properties was determined without a QA program, and tests have not been redone by the DCP or the IDVP

139. The testimony of PG&E, the IDVP, and the NRC regarding soils properties of the backfill surrounding the diesel fuel oil tanks was all based on the work of Harding Lawson Associates. (ITR 68, PG&E Exh. 155, p. 1; NRC Panel 2, ff. Tr. D2463, at 24; Tr. D763.) The IDVP performed a quality

assurance review of Harding Lawson Associates, and found that it implemented no quality assurance program for the Diablo Canyon soils work. (ITR 68, PG&E Exh. 155, p. 2.) PG&E has not reperformed any field tests, laboratory tests, or sampling done by Harding Lawson Associates. Also, it has not verified this work except by a general review for reasonableness of results. That review appears to have been done by only one or two persons and it is not clear if any of this review was documented. The testimony seems to indicate it was not. (Tr. D767; D773; D775; D798.) Though the IDVP reviewed the geologist's log and the data for reasonableness of results, geologist's log and compared data to the literature, it performed no physical tests. (ITR 68, PG&E Exh. 155, pp. 4-5.)

(2) Data on low strain shear modulus of the ASW and CWIC soil are not documented adequately

140. The evidence shows that the soil data in Figure 22 of ITR 68 (PG&E Exhibit 155), are not reliable as representations of the low strain shear modulus of soil surrounding the auxiliary saltwater piping since the source of the data, both as to sample test site and as to testing program, is not presented. The data were gathered from testing performed near the auxiliary saltwater piping and from near the diesel fuel oil tanks (ITR 68, PG&E Exh. 155, p. 43). However, the soils from tohse sites are of different types (PG&E Panel 2, ff. D651, at pp. 85-86), and Figure 22 does not specify which data were collected from which site (ITR 68, PG&E Exh. 155, Figure 22; Tr. D2555). Further, ITR 68 states that tests were performed for values of 500-3000 psf (ITR 68, PG&E Exh. 155, p. 43), but Figure 22 shows data extending to 4500 psf. No explanation is given in the ITR for how, where, or by whom the tests were done that yielded these data.

141. The Board finds that the unreliability of the data in Figure 22 casts doubt on the curve for shear modulus at low strain that appears in that figure. Further, the unreliability of the data also casts doubt on the curves in the ITR that depicts shear modulus at high strain. In soils analysis, curves depicting variation of shear modulus with strain are "normalized" (i.e., adjusted) at low strain values, so that inaccuracies in low strain curves, such as Figure 22 of ITR 68, may result in curves that do not accurately represent shear modulus at either low or high levels of strain because of improper normalization. (Tr. D2222.)

(3) Data on shear modulus at high strain presented in ITR 68 do not accurately represent in situ soil properties

142. Figures 23 and 24 of ITR 68, PG&E Exhibit 155, show data points derived from laboratory tests conducted by Harding Lawson Associates. (ITR 68, PG&E Exh. 155, pp. 42-43.) Soil samples gathered in the field and tested in the laboratory are often disturbed in the process of collection, storage, and transport. (Roesset, ff. D2206, at 20; Tr. D2558; D806.) Therefore, laboratory values are generally lower than field values. In soil properties testing (Roesset, ff. Tr. D2206, at 20), laboratory test data are usually adjusted by a correction factor to account for phenomena such as sample disturbance, and to make the data more representative of in situ condition (Roesset, ff. Tr. D2206, at 20; Tr. D2558).

143. However, appropriate correction factors are often difficult to determine, because they depend on the degree of sample disturbance. NRC expert witness, Dr. Costantino, said he could not estimate a particular correction factor unless he saw the soil sample come out of the tube. (Tr. D2559-60.) Dr. Roesset testified that appropriate correction factors for the laboratory data could be in the range of a factor of two. (Tr. D2223.)

Dr. Costantino for the NRC estimated a factor somewhat less than two. (Tr. D2560.) PG&E expert witness Dr. Seed testified that the appropriate correction factors for the ASW backfill would range from about 1.25 at low strain levels to about 1.0 at high strain levels, based on the fact that the backfill was highly compacted and would be less disturbed during sampling than an uncompacted soil. (Tr. D3118.)

144. No correction factors were applied to the laboratory data presented in Figures 23 and 24 of ITR 68, PG&E Exhibit 155, to make them more representative of in situ conditions. (Tr. D806; D2557-58.) This failure to apply correction factors causes in these figures to be inaccurate representations of the properties of the ASW and CWIC soils. Dr. Roesset testified that the curve in Figure 23 of ITR 68, representing the high strain values of shear modulus varying with shear strain of the backfill, would have to be raised, if the test data in that Figure were corrected to more realistically represent in situ values. (Tr. D2224.)

145. Raising the modulus curve would also affect the damping curves for the ASW/CWIC soil. Drs. Roesset and Costantino testified that the damping values for the auxiliary saltwater piping backfill shown by the curve in Figure 24 of ITR 68 (PG&E Exhibit 155) were already very high for the type of soil represented. (Roesset, ff. 2206, at 21; Tr. D2564.) Dr. Costantino stated that he would estimate the magnitude of damping as lower by a factor of two than what is presented in Figure 24. (Tr. D2564.)

146. Both Dr. Roesset and Dr. Seed testified that if the laboratory test data points in Figure 24 of ITR 68 were corrected to make them more representative of in situ conditions, the curve showing damping in that Figure would drop. (Tr. D2224; D3131.) The seismic response of the auxi-

liary saltwater piping and circulating water intake conditions could be affected by a variance in the shear modulus and damping values of the surrounding backfill. (Tr. D2224-55.) Therefore, unless the true properties of the backfill are known, the seismic qualification of these systems remains unproved.

147. The Board finds that neither PG&E nor the IDVP has produced evidence demonstrating the soil properties of the soil surrounding the auxiliary saltwater piping and the circulating water intake conduits in a consistent and well-documented fashion. The seismic qualification of these systems has not been shown and remains in doubt until the soil properties have been properly demonstrated and the piping and conduits shown qualified for such soil properties.

G. The IDVP Did Not Perform Independent Modeling of the Seismic Response of the Diablo Canyon Structures, Although Such Modeling Would Give Increased Confidence in the Design of Those Structures

148. Brookhaven National Laboratories performed independent modeling of the containment annulus and the buried diesel fuel tanks at the request of the Staff. The independent modeling done by Brookhaven consisted of obtaining design information as to the structure, member connectivity, mass distribution, soils data and other features of the annulus and the buried tanks, developing seismic response models independently of those of the applicant, and running the models to obtain final results. All Brookhaven work was done without reference to the modeling the DCP had done, until final results were compared. (SSER 18, Staff Exh. 36, section 3.6.)

149. The results of the Brookhaven modeling of the containment annulus revealed the importance of floor flexibility and local nodal participation in the seismic response of the annulus, effects not previously accounted

for by the applicant. The Brookhaven independent modeling also produced different response spectra, including different spectral peaks for both vertical and horizontal responses. (SSER 18, Staff Exh. 36, pp. C.3-92-93, 3-95.) Thus, the independent modeling revealed important features of the annulus response not revealed by the original PG&E modeling. These insights had sufficient value that the results of the Brookhaven modeling were relied on by the staff as a benchmark in understanding the seismic response of the containment annulus even after the annulus had been modified and reanalyzed by the applicant. (SSER 18, Staff Exh. 36, at C.3-5, C.3-9; Tr. D2574; Tr. D2575.)

150. In addition, the Brookhaven independent modeling of the buried diesel fuel tanks revealed that PG&E's model did not accurately represent the seismic response of the tanks and the fluid within the tanks. (SSER 18, Staff Exh. 36, section 3.6.6; Tr. D1935.) In response to the results of Brookhaven independent modeling of the buried diesel tanks, PG&E committed itself to further modeling and changes in its modeling of the tanks. (SSER 18, Staff Exh. 36, p. C.3-99.) This demonstrates the value of the independent modeling of the tanks.

151. Independent modeling of the type done by Brookhaven for the containment annulus and buried diesel fuel tanks is useful as an independent and unbiased basis for determining the seismic accuracy of a structure design. (Roesset ff. D2206 at 22-23; Tr. D2619.) Where, as in the case of the Brookhaven models, there are differences, the independent model may indicate problems or provide fresh insight. Certainly, disagreement of two models indicates that further investigation is needed. (Tr. D1938-39.) Where the results of such independent modeling are in close agreement with

the results of the original model, there is reason for increased confidence in the original results. (Tr. D1938; Tr. D1901.)

152. Although certain aspects of the seismic qualification of various structures at Diablo Canyon were independently modeled by the IDVP, the IDVP performed no independent modeling, of the type done by Brookhaven National Laboratories for the containment annulus and the buried diesel fuel tanks, of the complete seismic response of any building at Diablo Canyon. (Roesset, ff. D2206, at 22; Tr. D2619-20; Tr. D1939-44.) If independent modeling such as that done by Brookhaven of the complete seismic response of each building at Diablo Canyon were done, increased confidence in the design of each structure would result. (Roesset, ff. 2206, at 24; Tr. D2291-92.) Increased confidence would also result from independent modeling of each building using simplified models. (Tr. D2292; D2294-95.)

153. The Board finds that independent modeling of the seismic response of buildings, such as the modeling done by Brookhaven National Laboratories for the containment annulus and the buried diesel fuel tanks, would give added confidence in the design of the buildings at Diablo Canyon, as an unbiased check on the design and seismic response of those buildings. While more simplified models than the Brookhaven models could be used, such modeling should be done by the IDVP for each building at Diablo Canyon.

IV

PG&E HAS FAILED TO ANALYZE ALL THE JET IMPINGEMENT LOADS IT IS REQUIRED TO CONSIDER

A. PG&E Has Misconstrued the Requirements of Its License Application With Respect to Analysis of Jet Impingement Loads Inside Containment

154. PG&E's license application requires it to perform jet impingment analyses for high energy line breaks occurring inside containment. (PG&E

Panel 3, ff. Tr. D487, at 25.) However, PG&E testified that it believed the FSAR to be silent as to the specific temperature/ pressure criteria to be utilized for conducting high energy line break analyses inside containment. (Tr. D589.) As a result, PG&E used the criteria which had been developed for jet impingement and pipe whip analyses outside containment. (Tr. D589.) These criteria were set forth in section 3.6-16-17 of the FSAR. (Tr. D588-89.)

155. PG&E's interpretation of the criteria contained in that portion of the FSAR led it to the conclusion that an analysis was only required for lines which were subject to both high temperatures and high pressures. (Tr. D589.) Subsequent to reaching this conclusion, PG&E ascertained that though there did not appear to be criteria for high energy line breaks inside containment, there was a listing of lines inside containment, at page 3.6-11 of the FSAR, which definitely had to be analyzed for such breaks. (Tr. D589-90.) The lines listed were all subject to both high temperature and high pressure. (Tr. D589.)

156. PG&E's interpretation of section 3.6.4 of the FSAR is not consistent with the express language of section 3.6.4. This section provides, in pertinent part, as follows:

> "The following criteria and definitions apply to the selection of piping systems outside containment for evaluation of the dynamic effects associated with postulated pipe rupture.
>
> "1. All systems having a service temperature greater than 200°F or a design pressure greater than 275 psig are considered.
>
> "Open crack breaks are postulated to occur in the most adverse locations in piping having fluid temperature or pressure greater than the above." (Emphasis added.) (FSAR section 3.6.4, p. 3.6-16-17.)

Thus, contrary to PG&E's interpretation, there are circumstances in which

section 3.6.4 requires the consideration of jet impingement and pipe whip effects for pipes subject to either high temperature or high pressure.

157. However, in using section 3.6.4 of the FSAR, PG&E ignored the criteria for pipe whip restraints inside containment at 3.6-13-3.6-14 of the FSAR, which require restraints on pipes which are subject to either high temperature or high pressure (FSAR section 3.6-13-14.)

158. On cross-examination PG&E witness Connell conceded that there is no difference between the criteria to be used for postulating a break for pipe whip effects and jet impingement effects. (Tr. D600.) The Board finds that PG&E should have utilized the criteria set forth at 3.6-13-14 of the FSAR to guide its jet impingement analysis inside containment.

B. PG&E's Misconstruction of the Criteria Has Left Three Lines Unreviewed

159. In failing to utilize the correct criteria for its jet impingement analysis inside containment, PG&E failed to analyze jet impingement effects on three lines within containment. (Tr. D613-14.) As a result, the Board finds that PG&E has failed to meet the requirements of its license application with respect to the performance of jet impingement analyses inside containment and that such an analysis should be performed.

V

THERE IS NO ASSURANCE THAT THE PLANT AS BUILT IS CONSISTENT WITH THE DESIGN ANALYSES

A. Diablo Canyon Has Had a History of Configuration Control Deficiencies

160. In 1979, the NRC issued Investigation and Enforcement Bulletin No. 79-14 requiring licensee and permittees to verify that facilities were being constructed in conformity with their designs and with the analyses that established that the designs met their licensing requirements. PG&E's

response to I&E Bulletin 79-14 disclosed discrepancies between the as-built and the as-analyzed configuration of Unit 1 such that analyses had to be redone and some plant modifications had to be made to obtain the proper analysis. (Tr. D2946.)

161. Dr. Cloud's initial IDVP analyses of Phase I disclosed as-built vis-a-vis as-analyzed discrepancies. (Tr. D2948.)

162. BNL's analysis of vertical response in the containment annulus structure showed discrepancies between the as-built plant and the design drawings. (Tr. D2946-48.)

163. Institute of Nuclear Power Operations recommendations for changes in configuration control have highlighted deficient PG&E practices with respect to configuration control. (Gov. Exh. 11, p. 10; Hubbard, ff. Tr. D2084, at 13-14.)

B. The DCP's Configuration Control Practices Have Not Significantly Improved Upon PG&E's Historic Deficiencies

164. Generally, the DCP utilizes a combination of PG&E and Bechtel QA procedures. (ITR 41, PG&E Exh. 133, pp. 5-6.) However with respect to configuration control, the DCP uses PG&E Engineering Department procedures. (PG&E Exh. 161; PG&E Panel 1, ff. Tr. D224, at 32; Tr. D1709-10.)

165. Though PG&E has sought to modify some of their procedures to rectify past deficiencies (Tr. D462), configuration control errors have still been identified by the IDVP (Tr. D1639). These errors have been identified in EOI's 1120, 1121, 1123, 1124, 1133, 1135 and 1137. (Hubbard, ff. Tr. D2084, at 15.) In addition, numerous other configuration control discrepancies were documented in ITRs 59, 60, 61, 63 and 65. (PG&E Exhs. 149, 150, 151, 152, and 153; Hubbard, ff. Tr. D2084, at 16-17.)

166. These errors and discrepancies were so conspicuous they were

uncovered by the IDVP although it was not doing a program of checking drawings (Tr. D1641) or of confirming the configuration control product (Tr. D1635).

C. The Verification Program Does Not Supply the Missing Assurance That the Discrepancies Have Been Reconciled

167. The IDVP does not provide assurance that all discrepancies between the plant as built and as designed have been reconciled.

168. The IDVP has not verified that Unit 2 as built conforms to the design drawings and analyses. (Morrill, ff. Tr. D2906, at 2.)

169. The IDVP can only verify work which has been performed. Thus, to the extent that neither PG&E (prior to November 1981) nor the DCP (afterwards) has reconciled as-builts to design drawings and analyses, the IDVP can shed no light on the existence or adequacy of such a reconciliation.

170. Insofar as the DCP's design work is concerned, the as-built reconciliation process has not progressed to the point where even the procedure, let alone the configuration control product, could be checked. Though the IDVP, in ITR 41 (PG&E Exh. 133), concluded that the DCP as-built procedures had been effectively implemented (PG&E Exh. 133, p. 53; Tr. D1624-25), there is no basis in the record for such a conclusion. (Tr. D1624-36.) In fact, the checklists utilized by Mr. Reedy's organization expressly stated, with respect to the as-built process, that this aspect of the program could not be audited because not enough work had been completed at the time of the November 1982 audit to make a reasonable critique of it. (Gov. Exh. 48, pp. 31-33; Gov. Exh. 49, pp. 31-33; Tr. D1634-36.)

171. Though the IDVP performed an additional audit on March 17, 1983, that audit, which the documentation indicates was conducted in a single day (ITR 41, PG&E Exh. 133, p. 2; Tr. D1668), did not attempt to verify the as-

built process or any other formerly unauditable aspects of the DCP QA program, but rather was limited solely to verifying that the 24 conditions noted in the November audit had been corrected (Tr. D1704-05).

172. The Board therefore finds that the IDVP cannot be said to have verified the DCP as-built process, nor the configuration control product of that process.

173. PG&E's engineering procedures do not require that all drawings of safety-related structures, systems, and components be brought to as-built condition until one year after licensing. (PG&E Engineering Department Procedures 3.60N and 3.7, PG&E Exh. 161.) Thus, there can today be no assurance that the ITP has uncovered all discrepancies between the plant as built and the plant as analyzed.

174. Given the history of as-built discrepancies at Diablo Canyon, the PG&E commitment to bringing drawings of safety-related SS&Cs into conformance with design drawings and analyses does not satisfy the requirements of the Commission's regulations (Appendix B, Criteria III, VI, X, XVI) for prompt reconciliation of the plant as built with the design documents. (Hubbard, ff. Tr. D2084, at 17-18.)

175. The Board therefore finds that it is necessary, in order to establish that Diablo Canyon configuration control practices conform to the regulations, that all the as-built drawings be promptly reviewed and their conformance with design drawings and analyses be verified.

VI

THERE HAS BEEN NO VERTIFICATION THAT THE WESTINGHOUSE DESIGN OF SAFETY-RELATED EQUIPMENT MET LICENSING CRITERIA

176. In answers to interrogatories, PG&E admitted that the verifi-

cation program failed to verify that the design of safety related equipment supplied to PG&E by Westinghouse met licensing criteria. (Hubbard, ff. Tr. D2084, at 19-20.)

177. The only activities the IDVP has undertaken with respect to a review of Westinghouse's effort on Diablo Canyon have been:

(a) to verify that there was a process for controlling the interface between PG&E and Westinghouse and to sample a portion of the transmittal of the Hosgri seismic design spectra from PG&E to Westinghouse (Hubbard, ff. Tr. D2084 at 20; PG&E Panel 4, ff. Tr. D1088, at 2); and

(b) to verify the design interface between PG&E and Westinghouse with respect to the non-seismic design of the auxiliary feedwater system (PG&E Panel 4, ff. Tr. D1088, at 4).

178. Errors have been uncovered in the Westinghouse design work. BNL disclosed the fact that 30% of the Westinghouse samples taken by the IDVP contained errors, including, among other things, the incorrect use of tau filtering. (Hubbard, ff. Tr. D2084, at 22-24; ITR 11, PG&E Exh. 103.) Errors were found in the seismic qualification of the main control board. (Hubbard, ff. Tr. D2084, at 22-23; Tr. D1121-24.) The IDVP discovered the fact that transmittals from PG&E to Westinghouse sometimes did not identify to which unit the information was applicable. (ITR 42, PG&E Exh. 134, pp. 53-54; Tr. D1646-50, 1670-71.)

179. While the IDVP found that PG&E did not identify to which unit information transmitted to Westinghouse referred, the IDVP did not consider such a failing to be significant (ITR 42, PG&E Exh. 134, p. 53; Tr. D1648) and in fact testified that it was arguable whether the failure to identify

to which unit information referred was consistent with good QA practice (Tr. D1649). Staff witness Haas testified that PG&E's failure to identify for Westinghouse the appropriate unit for which design information was applicable constituted an interface problem comparable to earlier PG&E interface problems and that such interface failings can have an impact on quality. (Tr. D2955-56.) The Board finds that the PG&E-Westinghouse interface errors reflect an absence of sound design control practice and a violation of Criterion III of Appendix B.

180. The QA program applicable to the non-seismic design work performed by Westinghouse for Diablo Canyon was not audited by the NRC until 1973-74. (Tr. D1090, D1092.) The majority of the non-seismic design work performed for Unit 1 had already been completed by that time. (Tr. D1089-92.) Thus, no NRC audit has assessed the implementation of the Westinghouse QA program utilized for the majority of the Unit 1 non-seismic design work.

181. Westinghouse had some experience in seismic design reanalysis and had developed what it believed to be standard seismic design spectra which would envelop all potential seismic spectra. (Tr. D1135.) However, it discovered in working with the Hosgri spectra from Diablo Canyon that some Hosgri spectra exceeded its standard spectra in some instances. (Tr. D1135.) Furthermore, Westinghouse had never before had to utilize tau filtered spectra in any other of its seismic design analyses. (Tr. D1108.)

182. During the period when Westinghouse was performing its Hosgri seismic design reanalysis for Diablo Canyon, the NRC was auditing the overall Westinghouse QA program. However, it did not specifically audit the implementation of this Westinghouse program with respect to the Hosgri reanalysis. (Tr. D1108.) In the absence of a Diablo Canyon - specific NRC

audit of the Westinghouse non-seismic design and Hosgri reanalysis or an IDVP verification of the Westinghouse design product, no meaningful assurance has been provided that the Westinghouse design of safety-related equipment at Diablo Canyon meets all applicable licensing criteria. (Hubbard, ff. Tr. D2084, at 24.)

183. Accordingly, the Board finds that the applicant has failed to prove that the design of the nuclear steam supply system (NSSS) for either unit of Diablo Canyon was subject to a legally sufficient QA program.

184. A properly functioning QA program of a licensee performs assessments of the adequacy of work performed by contractors and suppliers of safety-related systems and equipment. (Appendix B, Criteria IV, VII.) In order for the verification program to provide the level of assurance equivalent to that provided by a satisfactory QA program, the Board finds that a verification of the Westinghouse design work is required. That verification should be of the actual design work applicable to Diablo Canyon and should be of a scope and depth comparable to the review a licensee would be expected to make of its NSSS vendor in order to satisfy its obligations under Appendix B.

VII

THE VERIFICATION PROGRAM'S METHODS ARE INADEQUATE TO ASSURE THAT ALL THE ROOT CAUSES OF THE DIABLO CANYON DESIGN ERRORS HAVE BEEN ASCERTAINED AND THAT ALL GENERIC CONCERNS STEMMING FROM THOSE ERRORS HAVE BEEN IDENTIFIED

A. The Verification Program Failed to Identify the Root Cause of Each Design Error

185. Root cause is the underlying basis that precedes and usually includes an effect or result. It is the same as the basic cause described

by the IDVP in section 6.3 of its Final Report (PG&E Exh. 90). Generic concern refers to the potential of each identified error to exist in a similar manner in other unreviewed parts of the plant. (Hubbard, ff. Tr. D2084, at 24-26.)

186. In the case of significant conditions adverse to quality, Criterion XVI of Appendix B requires the identification of the condition, its cause and corrective action to prevent its recurrence. Interpreting Criterion XVI in the context of the Diablo Canyon application, the Commission order (PG&E Exh. 86, attachment 1, at part 1(a)(5)(b)) and the Staff Letter (PG&E Exh. 87, at parts 1(b), 2(b) and 3(b)) require an assessment of the basic cause of all design errors found.

187. Both the IDVP and the ITP made general statements as to the basic cause of the design errors uncovered. (IDVP Final Report, sections 6.0, 6.3, 6.4 and 6.5, PG&E Exh. 90; PG&E Phase I Final Report section 1.8, PG&E Exh. 91; PG&E Phase II Final Report section 3.0; PG&E Exh. 92.) However, the basic causes identified related primarily to seismic design errors. (Hubbard, ff. Tr. D2084, at 27; Tr. D3003.) Moreover no attempt was made to correlate these basic causes with each of the design errors which had been identified. In fact, the IDVP affirmatively states that an identification of the basic cause of each and every design error was unnecessary. (IDVP Panel 1, ff. Tr. D1459, at 7-4). Thus, there is no objective evidence that the basic causes identified by the IDVP and the ITP are in fact responsible for each of the design errors uncovered. (Hubbard, ff. Tr. D2084, at 26-27.)

188. Absent a correlation between the basic causes listed and the design errors uncovered it is not possible to meet the corrective action

requirements of Criterion 16 of Appendix B or to comply with the Commission's November 19, 1981 order. (Hubbard, ff. Tr. D2084, at 26-27.)

B. The Verification Program Failed to Identify the Root Cause of Each QA Error

189. Neither the IDVP nor the ITP sought to identify and isolate the specific QA failure which allowed the subsequently discovered design errors to have gone undetected. (Hubbard, ff Tr. D2084, at 28-38.) In so doing they failed to assess the potential generic concern which can result from a failure to establish or implement QA procedures designed to detect such errors. (Hubbard, ff. Tr. D2084, at 28.) The IDVP's rationale for the failure to assess the generic significance of the QA failures to detect pre-November 1981 design errors was that it was assumed, in the search for other design errors, that the QA programs at issue were deficient. Therefore the search for other design errors would not have been expanded had each QA failing for each design error been identified. (IDVP Panel 1, ff. Tr. D1459, at 7-3.)

190. While this may constitute an acceptable explanation for the IDVP's failure to delineate a QA cause for each undetected error for pre-November 1981 design work, it does not explain why no such determination was made for design errors made by the DCP, inasmuch as the DCP's QA program was assumed to meet the requirements of Appendix B (PG&E Panel 5, ff. Tr. D847, at 9, 10) and to have been effectively implemented (IDVP Panel 1, ff. Tr. D1459, at 8-3).

191. PG&E, the DCP, and the IDVP all evinced the belief that QA auditors are not expected per se to find failures to meet design criteria. Rather their primary function is to see if engineering procedures have been followed. (PG&E Panel 5, ff. Tr. D847, at 7, 8; Tr. D972-975; Tr. D1644.)

Thus, the verification program did not look at the generic significance of QA failures because they did not believe this would enable them to detect engineering failures to meet design criteria. However, the Staff's position has been that without a thorough examination of the extent and implementation of QA program controls, an assessment of generic findings in the area of design control consistency will be inhibited. (SECY-82-414, PG&E Exh. 157.) Therefore, this Board cannot conclude that adequate assurance has been provided that all generic design errors have been identified.

C. The Failure to Correlate Root Causes and QA Deficiencies Precludes Assurance That Similar Errors Will be Discovered and Will Not Recur

192. The consequences of an approach which fails to correlate root causes and QA program deficiencies with specific design errors are demonstrated by the aftermath of PG&E's Look Back Review. One of the findings of this review states that consultants were "somehow" not included as suppliers of nuclear safety related services. No attempt was made to correlate any of the various causes with each of the contractors in such a way as to pinpoint or verify a specific cause for any particular contract. Furthermore the review refrained from even considering whether the cause of these errors was based on a lack of management commitment to QA or organizational dysfunction. (Tr. D1034-35.)

193. The review listed a number of programmatic and QA implementation deficiencies which had been identified and purportedly resolved:

a. Lack of formal training requirement in QA for personnel -- resolved in 1977 through issuance of a revised Engineering Department Manual;

b. Deficiencies in interface control between PG&E and its service contractors -- resolved in 1977 through issuance of a revised

Engineering Department Manual;

c. Failure to assure that up-to-date license commitments were being utilized by designers -- resolved through the project manager informing all design groups to verify commitments as current prior to use. (Gov. Exh. 34, pp. 5-7.)

194. On cross-examination Mr. DeUriarte testified that the cause of these deficiencies had been identified and no further problems had been identified with respect to those deficiencies. (Tr. D859-84.) He also testified that as of November, 1981, PG&E's QA program fully met all its license commitments. (Tr. D895.)

195. Almost immediately after testifying that all interface deficiencies with service contractors had been resolved by 1977 (Tr. D857-62), Mr. DeUriarte was forced to admit that, contrary to his testimony and the Look Back Review conclusions, a deficiency with respect to the PG&E interface with URS Blume was disclosed in 1978. (Tr. D893; Gov. Exhs. 43 and 44.)

196. Moreover, in the Project Assistance Corporation (PAC) report (Gov. Exh. 35) on the status of the PG&E QA program, which PG&E admitted contained no untrue statements (Tr. D3182), and in the EDS Nuclear Inc. Report (Gov. Exh. 36) on the status of PG&E QA and Engineering Department Manuals, it was demonstrated that, as late as 1982, PG&E had still failed to resolve deficiencies with respect to training, interface control, and the updating of license commitments and had not in fact yet met all its QA license commitments. (Gov. Exh. 35, pp. 3-4; Gov. Exh. 36, pp. 3, 5-7.)

197. Thus, the aftermath of the PG&E Look Back Review demonstrates how a program which does not correlate design errors with root causes and QA program deficiencies can fail to prevent the recurrence of these errors in

the future. Inasmuch as the verification program has admittedly adopted such an approach in its review of the root causes and the generic import of the design errors uncovered, it cannot provide assurance that no further design errors will be uncovered in Unit 1 or occur in Unit 2.

D. The IDVP Failed to Recognize Organizational Dysfunction and Management Shortcomings as Root Causes of the Design Errors

198. In addition to their other findings, the PAC Report (Gov. Exh. 35) and the EDS Nuclear Report (Gov. Exh. 36) demonstrated that PG&E's Look Back Review had failed to discover the root causes for the QA program's deficiencies. These root causes, which PG&E's Look Back Review failed to consider as possibilities, were:

a. Organizational dysfunction caused by multiple almost wholly independent quality assurance programs within the various PG&E departments which the corporate QA program is unable to control (Gov. Exh. 35, p. 5; Gov. Exh. 36, p. 1); and

b. The low organizational level at which the PG&E QA Department functioned thereby reflecting a lack of commitment to QA at the highest levels of management (PAC Report, Gov. Exh. 35, p. 6; EDS Nuclear Report, Gov. Exh. 36, p. 1).

199. These conclusions about the root causes of PG&E's QA deficiencies were echoed in the NRC Staff's assessment of the root causes of the Diablo Canyon mirror image design errors in its final Case Study C (Staff Exh. 54). In that report the Staff identified the fact that PG&E management was composed of individuals who believed that engineering could satisfactorily design a nuclear power plant without an overlaying QA organization (Staff Exh. 54, p. 6) and who failed to appreciate the potential merit of a formal institutionalized QA program (Staff Exh. 54, p. 7).

200. Even before the final Case Study C Report, the Staff had recognized that the management of PG&E bore a measure of responsibility for the breakdown in design quality assurance. (SSER 18, Staff Exh. 36, p. C.5-6; Tr. D2297.) In reviewing the DCP's description of the contributing causes of the design errors -- all of which were extrinsic to PG&E and its management (Staff Panel 5, ff. Tr. D3011, p. 2) — Mr. Schierling admitted that the DCP assessment did not reflect recognition by PG&E management of its own past shortcomings. (Tr. D3012.)

201. Three separate organizations, working independently, have concluded that a fundamental problem with the PG&E QA program was a lack of high-level management commitment to QA. The IDVP has failed to identify lack of management commitment to QA as a root cause of the QA deficiencies in PG&E's design effort. (IDVP Final Report, PG&E Exh. 90, section 6.0, et seq.)

202. The Board finds that the failure by the IDVP to recognize as a root cause the PG&E lack of managerial commitment to quality assurance demonstrates that the IDVP's approach to ascertaining root causes is not adequate. The Board further finds that the IDVP has not in fact ascertained all the root causes of PG&E's design QA failures and the full extent of their generic implications, and has therefore not complied with the Commission order, or with Criterion XVI of Appendix B.

VIII

THE APPLICANT HAS FAILED TO PROVE THAT THE RECENT DESIGN MODIFICATIONS WERE PERFORMED UNDER A QUALITY ASSURANCE PROGRAM WHICH MET THE REQUIREMENTS OF APPENDIX B

A. The PG&E QA Program for November 1981 Through August 20, 1982, Was Deficient

203. Between November 1981 and August 20, 1982, Diablo Canyon design

work was performed under the PG&E QA Program. (PG&E Panel 5, ff. Tr. D847, at p. 10.) There is no evidence the IDVP verified that the QA program being implemented by the DCP at the time was implemented effectively. (Tr.D1639.)

204. During this period DCP engineering worked under and followed the procedures set forth in the PG&E Engineering Department's Engineering Manual. (Tr. D3161.) At least 20 to 25 percent of the total design work performed by the DCP was performed at this time. (Tr. D3157, D1024.) In addition approximately 10% of the DCP design work resulting in modifications was performed during this period. (Tr. D3160.)

205. The Staff testified that until the spring of 1982 the PG&E QA program was still being implemented deficiently and that corrections of those deficiencies were still ongoing as late as mid-1982. (Tr.D3024-26.)

206. The PAC Report (Gov. Exh. 35, pp. 3-6) found that as of May 1982 the PG&E QA program still had not been able to fulfill all its QA license commitments and had severe organizational difficulties which were compounded by the QA department's lack of influence within the PG&E corporate structure. Mr. Haas testified that if the PAC Report conclusions were correct, then PG&E's QA program failed to meet the requirements of Appendix B with respect to the items identified. (Tr. D2969-70.)

207. Neither Mr. DeUriarte nor Mr. Skidmore became aware of the contents of the PAC Report until this hearing. (Tr. D3155-56, D3198-99.) When confronted with the PAC report conclusions, Mr. DeUriarte testified that they were not important enough to warrant prompt attention. (Tr. D3205.) Mr. DeUriarte's opinion in this regard is consistent with the fact that actions to correct the deficiencies noted in the PAC report are still incomplete. (Tr. D3156.) Though PG&E testified that some of the deficien-

cies in the PG&E QA Manual noted in the PAC Report were compensated for in other PG&E Manuals (Tr. D3152), neither the specific portions of these manuals where these deficiencies were overcome nor the manner in which they had been overcome were ever identified. Furthermore, on cross-examination, Mr. DeUriarte conceded that QA deficiencies caused by omissions from the QA Manual were not the only deficiencies noted by PAC. (Tr. D3227.) Thus, even if all PAC noted omissions were covered elsewhere, that fact alone would not resolve all the QA deficiencies identified by PAC.

208. Similarly, the EDS Nuclear Inc. Report (Gov. Exh. 36, pp. 5-7) found that the PG&E Engineering Manual, as of May 1982, was deficient in numerous respects. In rebuttal to the EDS Nuclear Report, PG&E presented the testimony of Mr. Stokes, a former employee of EDS Nuclear (Professional Qualifications of William J. Stokes, ff. Tr. D3145, at 2.) Though Mr. Stokes had not reviewed any of the manuals for design (Tr. D3189-90) and had not participated in the drafting of the report (Tr. D3189, 3225), he offered the opinion that the EDS Nuclear Report conclusions could not properly be read too broadly. However, on cross-examination, he conceded that the report's conclusions, if limited to the engineering manuals reviewed, were not unwarranted. (Tr. D3188-89.) He also admitted that the report was written in concert with a qualified engineer who had reviewed the engineering design manuals at issue. (Tr. D3223-24.) The actual authors of the report were not produced at the hearing.

209. As a result, approximately 25% of the total design work performed by the DCP and roughly 10% of its design work resulting in modifications was performed under a deficiently conceived and implemented QA program and an engineering manual likewise inadequate.

B. PG&E Has Failed to Prove That the QA Program In Place Since August 20, 1982, Meets Appendix B

210. In August 1982, the NRC approved the DCP's QA program. However, the NRC's approval of that program was based on little more than a review of the Bechtel Topical Report of matters included within the program and did not include a review of the actual program documents. (Tr. D2977.)

211. The NRC only reviewed the DCP's commitment to Appendix B, not its actual compliance with that regulation's requirements. (Tr. D2977-79.)

212. In November 1982, the IDVP conducted an audit of the implementation of the DCP QA Program based in part on checklists. (ITR 41, PG&E Exh. 133.) In that November audit, the IDVP found, among auditable aspects of the program, there were 24 failures to meet the requirements of the program. (IVDP Panel 1, ff. Tr. D1459, at 8-3.) These were attributed to the fact that the QA program, as of November 1982 was still just getting underway. (ITR. 41, PG&E Exh. 133, p. 11.)

213. At the same time, the IDVP also determined that more than 50 percent of the aspects of the DCP QA program in two of its checklists could not even be audited for compliance with procedures because the DCP had not yet begun to implement these aspects of its program. (Gov. Exhs. 48 and 49.)

214. During the period when this audit was taking place, the DCP was less than a month away from what has come to be known as the "big push" in construction of the modifications at Diablo Canyon. (Tr. D1662-1666.) Thus, the DCP QA program was still not fully functioning after the design work on a major portion of the seismic design modifications had taken place.

215. The NRC Staff testified that Criterion II of Appendix B requires that the QA program be in place and functioning before design work is done. (Tr. D2980.) Under cross-examination, Mr. Reedy conceded that a strict

construction of the requirements of Appendix B would indicate that the DCP QA program had not been implemented in a timely fashion. (Tr. D1699.)

216. In March 1983, the IDVP performed a follow-up audit to confirm that the 24 failures to meet program requirements had been met. However, this audit did not attempt to verify that the program requirements which had previously not been auditable because they had not yet been implemented had now been implemented satisfactorily. (Tr. D1704-05.) Indeed, in this March 1983 audit nothing more than a resolution of the 24 previously identified failures was attempted. (Tr. D1705-06.)

217. There is no evidence in the record that any of the attributes of the DCP QA program listed in Governor's Exhibits 48 and 49 described as not auditable or not applicable have ever been satisfactorily implemented.

218. In December 1982, the San Francisco Power Division of Bechtel Corporation performed an audit of the implementation of the DCP's QA program. (Gov. Exh. 33.) DCP witnesses conceded that this audit had uncovered failures to comply with procedures which were serious enough to require corrective action. (Tr. D939-47.)

219. In February and March 1983 the PG&E Engineering Quality Control Department performed an audit of the DCP's engineering manuals and determined that 50 percent of them contained at least 16 incorrect items. (Gov. Exh. 42.) Mr. DeUriarte testified that such a failing merits concern. (Tr. D1058.) PG&E's Engineering Quality Control Manager stated that such a result is not compatible with a "controlled quality program." (Gov.Exh. 40, p. 1.) Yet the DCP QA Manager testified that he was not concerned that his own QA personnel had not uncovered these deficiencies. (Tr. D961-962.)

220. Until March 11, 1983, the DCP had not distributed an engineering

instruction depicting the interface matrix for contractors involved in the design of Unit 1 and by that date the DCP had not yet distributed an engineering instruction depicting the interface matrix for contractors involved in the design of Unit 2. (PEI-5; Gov. Exhs. 37, 38, 39; Tr. D925-34.) Inadequacies in deseign interface had been known at least since discovery of the mirror-image error. The Board finds the failure of PG&E to implement formal procedures for design interface is a failure to take timely corrective action in compliance with Criterion XVI of Appendix B and demonstrates a continuing failure to PG&E to appreciate its QA obligations.

221. Criterion XVIII requires that comprehensive audits be undertaken to verify compliance with all aspects of a quality assurance program. One aspect of a quality assurance program involves verifying or checking the adequacy of design. In the DCP, the individuals responsible for verifying or checking the adequacy of design documents do not perform audits. (Tr. D976-78.) Instead, audits are performed by QA Department personnel. However, QA Department personnel are not required or expected to verify or check, by virtue of their audits, whether design documents meet the design criteria for them. (Tr. D972-75.) The Board finds that the DCP conducts no audits to verify whether design documents meet all design criteria and thus fails to meet the requirements of Criterion XVIII.

CONCLUSIONS OF LAW

1. The applicant has failed to satisfy the requirements of section 50.57(a)1, in that:

a. It has failed to establish the quality of the design of Diablo Canyon Unit 1 and Unit 2 by a verification program that either establishes the design to fully meet the licensing criteria and regula-

tory requirements or that subjects the design to a level of scrutiny equivalent to that of a lawfully adequate QA program;

b. It has not met its FSAR commitment to perform a jet impingement analysis on all piping inside containment which is subject to pressures over 275 psig or temperatures over 200 degrees fahrenheit;

c. It has not demonstrated that its configuration control practices conform to the requirements of Criteria III, VI, X, and XVI of Appendix B to 10 C.F.R. Part 50;

d. It has not demonstrated that in procuring the NSSS for Diablo Canyon it met the requirements of Criteria IV, VII, and XVIII of Appendix B to 10 C.F.R. Part 50;

e. It has not demonstrated that in attempting to ascertain the root cause and generic implications of the design errors uncovered it has conformed its conduct to the provisions of Criterion XVI of Appendix B to 10 C.F.R. Part 50;

f. It has not demonstrated that the DCP QA program under which the recent design modifications to Diablo Canyon were conceived and implemented was in compliance with the requirements of Appendix B to 10 C.F.R. Part 50.

2. The applicant has failed to comply with General Design Criterion II and with applicable licensing criteria in that the seismic design of all structures at Diablo Canyon has not been shown to be qualified for all effects of the applicable earthquakes, and the seismic response of all structures has not been shown to be within allowable limitations specified in the licensing criteria.

3. The IDVP has failed to comply with the commission order in the

following respects:

a. It failed to verify a sample of the design work of each service-related contractor;

b. It failed to obtain and use the expertise of a qualified statistician;

c. It failed to identify all deviations in the design of Unit 1 from the licensing criteria and regulatory standards and, instead, took it upon itself to recast the objective of the IDVP by limiting its objectives to the identification of all violations of the licensing criteria and regulatory standards the IDVP deemed to be safety-significant;

d. It failed to identify all the root causes of the design errors uncovered at Diablo Canyon.

* * * * * *

Appendix A

ISSUES LITIGATED IN THE REOPENED
DESIGN QUALITY ASSURANCE HEARINGS

Upon the motions of the Governor and the joint intervenors and in acordance with the concessions of the applicant and the staff, the record in the Diablo Canyon operating license proceeding was reopened on the issue of design quality assurance. The primary focus of the reopened proceeding, however, has now moved beyond the question of whether the applicant can demonstrate that the IDVP and the ITP verify the correctness of the Diablo Canyon design. The licensing criteria contained in the PSAR, FSAR, Hosgri Report, SER, SER Supplenments and other licensing documents are outside the scope of the issues in this reopened proceeding and are not subject to challenge, except to the extent that such criteria may have been modified in the verification program. The Governor and the joint intervenors assert that the verification programs have failed in the following respects:

1. The scope of the IDVP review of both the seismic and non-seismic aspects of the designs of safety-related systems, structures and components (SS&C's) was too narrow in the following aspects:

(a) The IDVP did not verify samples from each design activity (seismic and non-seismic).

(b) In the design activities the IDVP did review, it did not verify samples from each of the design groups in the design chain performing the design activity.

(c) The IDVP did not have statistically valid samples from which to draw conclusions.

(d) The IDVP failed to verify independently the analyses but merely checked data of inputs to models used by PG&E.

(e) The IDVP failed to verify the design of Unit 2.

2. The scope of the ITP review of both the seismic and non-seismic aspects of the designs of the safety-related systems, structures and components (SS&C's) was too narrow in the following aspects:

(a) The ITP did not verify samples from each design activity (seismic and non-seismic).

(b) In the design activities the ITP did review, it did not verify samples from each of the design groups in the design chain performing the design activity.

(c) The ITP did not have statistically valid samples from which to draw conclusions.

(d) The ITP has failed systematically to verify the adequacy of the design of Unit 2.

3. In various situations listed below, the ITP used improper engineering standards to determine whether design activities met license criteria. In some of these situations, the IDVP either used or approved the use of such improper standards or did not verify them at all.

(f) The ITP's modeling of the soil properties for the containment and auxiliary buildings was improper in that:

(i) in the soil structure interaction analysis of containment for the DE and the DDE, use of boundary motion inputs to the model were improperly used;

(ii) the soil structure interaction analysis for containment for the DE and the DDE uses a 7 percent damping value for rock, which is unconservative, especially for the DE;

(iii) the dynamic analyses of the containment for all earthquakes omit any analysis of uplifting of the foundation mat;

(iv) the modeling of the soil springs for the auxiliary building does not specify soil properties;

(v) in the modeling of the soil springs for the auxiliary building, the motion inputs to the lower ends of the springs does not account for all soil structure interaction phenomena that could be expected.

(o) The ITP has not demonstrated, and the IDVP has not verified, that the DCP modeling of the seismic response of the fuel handling building is proper, in that the DCP has not adequately justified the use of the translational and torsional response of the auxiliary building as input to the fuel handling building nor has it demonstrated the validity of the dynamic degrees of freedom selected.

(p) The ITP has not demonstrated, and the IDVP has not verified, that the DCP seismic model of the slabs in the auxiliary building is proper, in relation to the use of vertical and rotational springs to model the columns, and the motions used as input at the ends of the springs not connected to the slabs. In addition, in the study of the diaphragms, the ITP has not adequately accounted for the

inplane flexibility of these slabs, and has not adequately demonstrated that stresses are within allowable limits at all elevations.

(q) The ITP has not demonstrated and the IDVP has not verified, that the soils analysis for the buried diesel fuel oil tanks is proper in that the values of the exponent shown in figure 14 of ITR 68 have not been demonstrated to be appropriate and the variation of shear velocity with depth is not properly justified.

(r) The ITP has not demonstrated and the IDVP has not verified that the soils analysis for the auxiliary saltwater piping and circulating water intake conduits is proper in that the selection of the modulus versus strain curve utilized is not justified.

(s) The ITP has not demonstrated and the IDVP has not verified that the seismic analysis of the turbine building is proper in that bolt bearing capacities were taken from an inappropriate source.

(t) The ITP has not demonstrated and the IDVP has not verified that the seismic analysis of the turbine building is proper in that the use of four different models for the vertical analysis has not been justified.

4. The IDVP accepted deviations from the licensing criteria without providing adequate engineering justification in the following respects:

a. Contrary to the requirements of FSAR Section 17.1 regarding compliance of the as-built installation with the design documents, the IDVP review of the AFWS disclosed that the as-built installation failed to meet the design drawings in that (i) a steam trap on the turbine-driven AFW pump steam supply line is not provided and (ii) there are discrepancies in the arrangement of the long-term cooling water supply line.

b. Contrary to FSAR Section 8.3.3, the electrical design does not fully comply with the commitments regarding separation and color coding.

h. Contrary to PG&E's September 14 and December 28, 1978, licensing commitments, CRVPS equipment identified in the FSAR as necessary to maintain control room habitability during safe shutdown has not been evaluated regarding the effects of a moderate energy pipe break.

i. The fire protection for the motor driven AFW pump room is not consistent with the PG&E licensing commitment for fire zone separation as stated in its November 13, 1978, Supplemental Information for Fire Protection Review ("SIFPR") in that:

   1) there is a large grated ventilation opening in the ceiling of the room;

   2) a fire damper has gaps when it is closed.

j. The fire protection for the AFW pump room is not consistent with the PG&E licensing commitment for cable separation as stated in its SIFPR of November 13, 1978, in that:

   1) the pumps for the motor driven AFW pumps and the control circuitry for a flow control valve necessary for operation of the turbine driven AFW pump are located in a single fire zone;

   2) cables for some AFW circuits are not routed in accord with descriptions in the SIFPR and four AFW circuits PG&E committed to identify and review in the SIFPR were not included in that document.

k. Contrary to the licensing commitment set forth in its SIFPR of November 13, 1978, each of the three 4160 volt cable spreading rooms has a ventilation opening leading up to the 4160 volt switchgear rooms.

l. Contrary to FSAR Section 3.6, possible jet impingement loads have not been considered in the design and qualification of safety-related piping and equipment inside containment.

q. Contrary to PG&E's December 28, 1979, licensing commitment letter to the NRC, modifications to protect two Auxiliary Feedwater valves from the effects of moderate energy line breaks were not implemented.

r. Contrary to the licensing commitment to maintain minimum system redundancy as stated in FSAR Section 3.6A (NSC evaluation of pipe break outside containment), four components were identified for which high energy line cracks could cause temperatures in excess of the specification temperatures of the components.

s. Contrary to the licensing commitment to maintain minimum system redundancy as stated in FSAR Section 3.6A (NSC evaluation of pipe break outside containment), a conduit was identified whose failure due to a high energy line crack could eliminate redundant Auxiliary Feedwater system flow.

t. Contrary to the FSAR Section 8.3 commitment to provide switchgear buses with adequate short circuit interrupting capability, the calculated duties for circuit breakers on 4160 V buses F, G, and H were above the nameplate ratings for those buses.

u. Contrary to single failure criteria stated in FSAR Section 3.1.1, reviews of the Auxiliary Feedwater and Control Room Ventilation and Pressurization systems identified circuit separation and single failure deficiencies. Similar deficiencies were identified in additional verification reviews, which included other safety-related systems.

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

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

7. 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.

8. The ITP failed to develop and implement in a timely manner a design quality assurance program in accordance with 10 C.F.R. 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.

9. Contrary to General Design Criteria 44 (GDC-44) of Appendix A to 10 C.F.R. Part 50, PG&E has failed to provide adequate assurance of component cooling water system (CCWS) heat removal safety function capability in that the maximum ocean water temperative of 64 degrees F. is not conservative because it has already been exceeded in [illegible] Furthermore, a technical specification limitation [illegible] permits plant operation at reduced

power levels in lieu of enlarging the capacity of the CCWS does not provide an equivalent level of safety as compliance with the requirements of GDC-44 (SSER 16 (Aug. 1983) and September 1983 ocean water temperature readings).

Appendix B

WITNESSES TESTIFYING IN THE REOPENED
DESIGN QUALITY ASSURANCE HEARINGS

PANEL NUMBER	WITNESSES	DIRECT TESTIMONY BEGINS FOLLOWING	ISSUES
	APPLICANT'S WITNESSES		
PG&E 1	G. Cranston, G. Moore, R. Anderson, W. White, L. Shipley	D224	1, 2, 5
PG&E 2	H. Seed, R. Anderson, L. Shipley, W. White	D551	3
PG&E 3	E. Connell, G. Moore, R. Anderson, W. Yahlstrom	D487	4, 9
PG&E 4	R. Wiesemann, J. Hoch,	D1088	6
PG&E 5	C. Dick, M. Jacobson, S. Skidmore, T. DeUriarte, G. Moore	D847	7, 8
PG&E 6	S. Kaplan, R. Anderson	D1160	1(c) & 2(c)
IDVP 1	W. Cooper, R. Cloud, J. Krechting, R. Reedy	D1458	1, 2, 5-8
IDVP 2	R. Wray, R. Cloud, J. Biggs, M. Holley	D1843	3
IDVP 3	J. Krechting, W. Cooper	D2039	4
	GOVERNOR'S WITNESSES		
	R. Hubbard	D2084	5-8
	J. Roesset	D2206	3
	G. Apostolakis	D2313	1, 2, 7
	JOINT INTERVENORS' WITNESSES		
	F. Samaniego	D2392	1

PANEL NUMBER	WITNESSES	DIRECT TESTIMONY BEGINS FOLLOWING	ISSUES
	STAFF WITNESSES		
Staff 1	J. Knight, H. Schierling, J. Wermiel	D2649	1, 2
Staff 2	J. Knight, P. Kuo, H. Polk C. Miller, C. Costantino, A. Philippacopoulos, P. Wang	D2463	3
Staff 3	J. Wermiel, J. Knight	D2864	4
Staff 4	J. Knight	D2864	4
Staff 5	P. Morrill, W. Haass, J. Knight, H. Schierling W. Altman	D2864	4
Staff 6	J. Wermiel	D2864	9
	APPLICANT'S REBUTTAL WITNESSES		
Rebuttal 1	R. Cloud, H. Seed, W. White		3
Rebuttal 2	G. Moore, S. Skidmore, T. DeUriarte, M. Jacobson, L. Gouveia, W. Stokes		8

Appendix C

EXHIBITS ADMITTED IN THE REOPENED
DESIGN QUALITY ASSURANCE HEARINGS

NUMBER	DESCRIPTION	OFFERED	ADMITTED
	GOVERNOR'S EXHIBITS		
Gov. 11	2/12/82 L: Wilkinson (INPO) Mielke	D-2085	D-2087
Gov. 12	11/2/82 BNL Review of ITR-11, Rev. 0	D-2085	D-2087
Gov. 13	10/12/81 L: Crane-Engelken transmitting LER on annulus error.	D-2085	D-2087
Gov. 14	11/6/81 NRC Region V Inspection Report 50-275/81-29 & 50-323/81-18	D-2085	D-2087
Gov. 15	10/11/82 Potential Program Resolution Report EOI 7002, Rev. 0 (Jet Impingement)	D-2085	D-2087
Gov. 16	7/26/83 Open Item Report - EOI 7002, Rev. 5 (Jet Impingement)	D-2085	D-2087
Gov. 17	9/13/82 Open Item Report - EOI 8010 Rev. 0 (valve added, could result in excess pressure)	D-2085	D-2087
Gov. 18	3/4/83 Error Report - EOI 8010, Rev. 8	D-2085	D-2087
Gov. 19	6/1/83 Program Resolution Report EOI 8010, Rev. 11	D-2085	D-2087
Gov. 20	10/4/82 Open Item Report - EOI 8017, Rev. 0 (Electrical Control Transfer switch - separation criteria)	D-2085	D-2087
Gov. 21	10/12/82 Open Item Report - EOI 8022, Rev. 0 (circuit breakers	D-2085	D-2087
Gov. 22	3/10/83 Error Report - EOI 8022, Rev. 5 (circuit breakers)	D-2085	D-2087
Gov. 23	10/12/82 Open Item Report - Rev. 0 (Loca Conditions - 480 Volt Systems)	D-2085	D-2087
Gov. 24	3/11/83 Program Resolution Report EOI 8023, Rev. 5 (Loca Conditions- 480 Volt Systems)	D-2085	D-2087

NUMBER	DESCRIPTION	OFFERED	ADMITTED
Gov. 25	10/29/82 Open Item Report - EOI 8060, Rev. O (Pump Pressure Control System)	D-2085	D-2087
Gov. 26	3/15/83 Error Report - EOI 8060, Rev. 5	D-2085	D-2087
Gov. 32	2/82 Classification of SS&Cs for Diablo	D-1447	D-1447
Gov. 33	1/12/83 M:Kellermann - Moore: Audit 317 Package	D-936	D-936
Gov. 34	11/2/82 M:DeUriarte - Raymond transmitting. Look Back Review Summary of PG&E Design Activities	D-857	D-857
Gov. 35	5/82 Review of the PG&E QA Manual for Nuclear Power Plants: Summary Report	D-902	D-902
Gov. 36	6/7/82 L:Polivka - Dodd transmits Project Summary Report for PG&E by EDS Nuclear, Inc.	D-996	D-996
Gov. 37	8/10/82 DCP Instruction No. 5, Rev. O - Design Interfaces	D-934	D-934
Gov. 38	10/29/82 DCP Instruction No. 5, Rev. 1 - Design Interfaces	D-934	D-934
Gov. 39	3/11/83 DCP Instruction No. 5, Rev. 2, Design Interfaces	D-934	D-934
Gov. 40	4/21/83 M:Ralston-Brand transmits Audit EQ-8303 on Engineering Dept. Manual Control	D-954	D-954
Gov. 41	Graph - Variation of Shear Modulus with Shear Strain	D-782	D-782
Gov. 42	4/8/83 Table - Engineering Manual Audit	D-957	D-957
Gov. 43	4/26/79 Nonconformance Report	D-894	D-895
Gov. 44	5/8/79 Nonconformance Report - Design Interface	D-894	D-895
Gov. 45	7/14/80 Article by Kaplan & Garrick - "On the Quantitative Definition of Risk"	D-1336	D-1446

NUMBER	DESCRIPTION	OFFERED	ADMITTED
Gov. 46	6/11/81 Article by Kaplan "Safety Goals and Related Questions"	D-1346	D-1446
Gov. 47	10/15/82 L:Cooper - Eisenhut in Response to Region V Letter ("All")	D-1463	D-1464
Gov. 48	11/11-22/82 - R.F. Reedy Checklist Audit No. 014-003-A-03-6	D-1629	D-1630
Gov. 49	11/11-22/82 - R.F. Reedy Checklist Audit No. 014-003-A-03-5	D-1629	D-1630
Gov. 50	12/1/82 - Audit Notes (By Norris), Audit No. 014-003-A03-7	D-1654	D-1657
Gov. 51	3/15/83 - L:Krechting - Cooper transmits draft of ITR 14 ("Bullshit Comments")	D-1564	D-1586
Gov. 52	Draft of ITR 14 (Re: Representative samples)	D-1606	D-1607
Gov. 53	5/2/83 - Page 3.5-8 of IDVP Final Report. Rev. 0	D-1553 D-1554	D-1554
Gov. 54	6/27/83 - Page 3.5-8 of IDVP Final Report. Rev. I	D-1553 D-1554	D-1554
Gov. 55	Safety & Evaluation Report: Review of Diablo Canyon Turbine building	D-2578	D-2634
Gov. 60	9/1/83 M:Rubinstein - Romney - Reactions on PG&E Evaluation Spot Welds	D-2602	D-2770

NUMBER	DESCRIPTION	OFFERED	ADMITTED
	PG&E EXHIBITS		
PG&E 86	11/19/81 Commission Order (CLI-81-30	D-247	D-251
PG&E 87	11/19/81 NRC Staff Letter	D-247	D-251
PG&E 88	3/29/82 Design Verification Program Management Plan, Phase I	D-247	D-251
PG&E 89	6/18/82 Design Verification Program Management Plan, Phase II	D-247	D-251
PG&E 90	10/10/83 IDVP Final Report	D-247	D-251
PG&E 91	10/14/83 PG&E Phase I Final Report	D-247	D-251
PG&E 92	10/11/83 PG&E Phase II Final Report	D-247	D-251
PG&E 93	ITR 1 (Rev. 1) 10/22/82: Additional Verification and Additional Sampling Effective 10/15/82	D-247	D-251
PG&E 94	ITR 2 (Rev. 0) 6/23/82: Evaluation of the Quality Assurance Program and Implementation Reviews	D-247	D-251
PG&E 95	ITR 3 (Rev. 0) 7/16/82: Tanks	D-247	D-251
PG&E 96	ITR 4 (Rev. 0) 7/23/82: Shake Table Testing	D-247	D-251
PG&E 97	ITR 5 (Rev. 0) 8/19/82: Design Chain	D-247	D-251
PG&E 98	ITR 6 (Rev. 0) 9/10/82: Auxiliary Building	D-247	D-251
PG&E 99	ITR 7 (Rev. 0) 9/17/82: Electrical Raceway Supports	D-247	D-251
PG&E 100	ITR 8 (Rev. 0) 10/ 5/82: Verification Program for PG&E Corrective Action	D-247	D-251
PG&E 101	ITR 9 (Rev. 0) 10/15/82: Development of the Safety-Related Contractor List for Non-Seismic Design Work Performed Prior to 6/1/78	D-247	D-251
PG&E 102	ITR 10 (Rev. 0) 10/29/82: Verification of Design Analysis Hosgri Spectra	D-247	D-251

NUMBER	DESCRIPTION	OFFERED	ADMITTED
PG&E 103	ITR 11 (Rev. 0) 11/ 2/82: PG&E - Westinghouse Seismic Interface Review	D-247	D-251
PG&E 104	ITR 12 (Rev. 0) 11/ 5/82: Piping	D-247	D-251
PG&E 105	ITR 13 (Rev. 0) 11/ 5/82: Soils-Intake Structure	D-247	D-251
PG&E 106	ITR 14 (Rev. 2) 7/25/83: Verification of the Pressure, Temperature, Humidity, and Submergence Environments Used for Safety-Related Equipment Specification Outside Containment for Auxiliary Feedwater System and Control Room Ventilation and Pressurization System	D-247	D-251
PG&E 107	ITR 15 (Rev. 0) 12/10/82: HVAC Duct and Duct Supports	D-247	D-251
PG&E 108	ITR 16 (Rev. 0) 12/ 8/82: Soils-Outdoor Water System Storage Tanks	D-247	D-251
PG&E 109	ITR 17 (Rev. 0) 12/14/82: Piping: Additional Sample	D-247	D-251
PG&E 110	ITR 18 (Rev. 1) 5/24/83: Verification of the Fire Protection Provided for Auxiliary Feedwater System, Control Room Ventilation and Pressurization System, Safety-Related Portion of the 4160 V Electrical System	D-247	D-251
PG&E 111	ITR 19 (Rev. 0) 12/16/82: Verification of the Post-LOCA Portion of the Radiation Environments Used for Safety-Related Equipment Specification Outside Containment for Auxiliary Feedwater System and Control Room Ventilation and Pressurization System	D-247	D-251
PG&E 112	ITR 20 (Rev. 2) 7/25/83: Verification of the Mechanical/Nuclear Design of the Control Room Ventilation and Pressurization System	D-247	D-251
PG&E 113	ITR 21 (Rev. 1) 5/ 3/83: Verification of the Effects of High Energy Line Cracks and Moderate Energy Line Breaks for Auxiliary Feedwater System and Control Room Ventilation and Pressurization System	D-247	D-251

NUMBER	DESCRIPTION	OFFERED	ADMITTED
PG&E 114	ITR 22 (Rev. 2) 7/25/83: Verification of the Mechanical/Nuclear Portion of the Auxiliary Feedwater System	D-247	D-251
PG&E 115	ITR 23 (Rev. 1) 5/27/83: Verification of High Energy Line Break and Internally Generated Missile Review Outside Containment for Auxiliary Feedwater System and Control Room Ventilation and Pressurization System	D-247	D-251
PG&E 116	ITR 24 (Rev. 1) 5/ 4/83: Verification of the 4160 V Safety-Related Electrical Distribution System	D-247	D-251
PG&E 117	ITR 25 (Rev. 1) 4/29/83: Verification of the Auxiliary Feedwater System Electrical Design	D-247	D-251
PG&E 118	ITR 26 (Rev. 1) 5/ 2/83: Verification of the Control Room Ventilation and Pressurization System Electrical Design	D-247	D-251
PG&E 119	ITR 27 (Rev. 2) 7/25/83: Verification of the Instrument and Control Design of the Auxiliary Feedwater System	D-247	D-251
PG&E 120	ITR 28 (Rev. 2) 7/25/83: Verification of the Instrument and Control Design of the Control Room Ventilation and Pressurization System	D-247	D-251
PG&E 121	ITR 29 (Rev. 0) 1/20/83: Design Chain - Initial Sample	D-247	D-251
PG&E 122	ITR 30 (Rev. 0) 1/12/83: Small Bore Piping Report	D-247	D-251
PG&E 123	ITR 31 (Rev. 1) 8/ 4/83: HVAC Components	D-247	D-251
PG&E 124	ITR 32 (Rev. 1) 4/ 1/83: Pumps	D-247	D-251
PG&E 125	ITR 33 (Rev. 1) 4/28/83: Electrical Equipment Analysis	D-247	D-251
PG&E 126	ITR 34 (Rev. 1) 3/24/83: Verification of Diablo Canyon Project Efforts by SWEC	D-247	D-251
PG&E 127	ITR 35 (Rev. 0) 4/ 1/83: IDVP Verification Plan for Diablo Canyon Project Activities	D-247	D-251

NUMBER	DESCRIPTION	OFFERED	ADMITTED
PG&E 128	ITR 36 (Rev. 1) 6/20/83: Final Report on Construction QA Evaluation of Guy F. Atkinson Company	D-247	D-251
PG&E 129	ITR 37 (Rev. 0) 2/23/83: Valves	D-247	D-251
PG&E 130	ITR 38 (Rev. 2) 6/20/83: Final Report on Construction Quality Assurance Evaluation of Wismer and Becker	D-247	D-251
PG&E 131	ITR 39 (Rev. 0) 2/25/83: Soils-Intake Structure Bearing Capacity and Lateral Earth Pressure	D-247	D-251
PG&E 132	ITR 40 (Rev. 0) 3/ 9/83: Soils-Intake Structure Sliding Resistance	D-247	D-251
PG&E 133	ITR 41 (Rev. 0) 4/19/83: Corrective Action Program and Design Office Verification	D-247	D-251
PG&E 134	ITR 42 (Rev. 0) 4/13/83: RFR IDVP Phase II Review and Audit of PG&E Co. and Design Consultants for Diablo Canyon Unit 1	D-247	D-251
PG&E 135	ITR 43 (Rev. 0) 4/14/83: Heat Exchangers	D-247	D-251
PG&E 136	ITR 44 (Rev. 0) 4/15/83: Shake Table Test Mounting of Class 1E Electrical Equipment	D-247	D-251
PG&E 137	ITR 45 (Rev. 0) 5/17/83: Additional Verification of Redundancy of Equipment and Power Supplies in Shared Safety-Related Systems	D-247	D-251
PG&E 138	ITR 46 (Rev. 0) 6/27/83: Additional Verification of Selection of System Design Pressure and Differential Pressure Across Power-Operated Valves	D-247	D-251
PG&E 139	ITR 47 (Rev. 0) 6/27/83: Additional Verification of Environmental Consequences of Postulated Pipe Ruptures Outside of Containment	D-247	D-251
PG&E 140	ITR 48 (Rev. 0) 7/27/83: Additional Verification of Jet Impingement Effects of Postulated Pipe Ruptures Inside Containment	D-247	D-251

NUMBER	DESCRIPTION	OFFERED	ADMITTED
PG&E 141	ITR 49 (Rev. 0) 6/23/83: Additional Verification of Circuit Separation and Single Failure Review of Safety-Related Electrical Equipment	D-247	D-251
PG&E 142	ITR 50 (Rev. 0) 7/22/83: Containment Annulus Structure Vertical Seismic Verification	D-247	D-251
PG&E 143	ITR 51 (Rev. 1) 9/21/83: Containment Annulus Structure - Verification of Corrective Action	D-247	D-251
PG&E 144	ITR 54 (Rev. 1) 10/ 3/83: Containment Building	D-247	D-251
PG&E 145	ITR 55 (Rev. 1) 10/ 1/83: Auxiliary Building	D-247	D-251
PG&E 146	ITR 56 (Rev. 1) 9/24/83: Turbine Building	D-247	D-251
PG&E 147	ITR 57 (Rev. 1) 9/ 8/83: Fuel Handling Building	D-247	D-251
PG&E 148	ITR 58 (Rev. 1) 10/ 1/83: Intake Structure	D-247	D-251
PG&E 149	ITR 59 (Rev. 1) 9/24/83: Large Bore Piping	D-247	D-251
PG&E 150	ITR 60 (Rev. 1) 10/ 3/83: Large and Small Bore Pipe Supports	D-247	D-251
PG&E 151	ITR 61 (Rev. 1) 10/ 2/83: Small Bore Piping	D-247	D-251
PG&E 152	ITR 63 (Rev. 1) 10/ 2/83: HVAC Ducts, Electrical Raceways, Instrument Tubing and Associates Supports	D-247	D-251
PG&E 153	ITR 65 (Rev. 1) 10/11/83: Rupture Restraints	D-247	D-251
PG&E 154	ITR 67 (Rev. 1) 9/ 9/83: Equipment	D-247	D-251
PG&E 155	ITR 68 (Rev. 1) 10/ 4/83: Verification of HLA Soils Work Verification of HLA Soils Work	D-247	D-251
PG&E 156	3/1/82 M:Dircks - Commissioners Secy-82-89, Verification Program Phase II Recommendations	D-251	D-254
PG&E 157	10/13/82 M:Dircks - Commissioners Secy-82-414, Verification Program Phase II Recommendations	D-251	D-254

NUMBER	DESCRIPTION	OFFERED	ADMITTED
PG&E 158	3/8/82 M:Chilk - Dircks, Commission Approval of Phase I	D-251	D-254
PG&E 159	12/9/82 M:Chilk - Dircks, Commission Approval of Phase II	D-251	D-254
PG&E 160	8/5/83 DCP Project Engineer's Instruction No. 13, Rev. 1 - Unit 2 Review Procedure	D-251	D-254
PG&E 161	8/15/83 PG&E Engineering Dept. Procedures 3.6 ON and 3.7 - "As-Builts"	D-251	D-254
PG&E 162	2/18/76 Hearings before Joint Committee on Atomic Energy		
PG&E 163	5/17/83 IDVP Program Procedure Interface Bet. IDVP Participants, DCP & Designated Other Parties		

NUMBER	DESCRIPTION	OFFERED	ADMITTED
	JOINT INTERVENORS' EXHIBITS		
JI 128	7/83 NBC "QA Case Study Working Paper, Case C," Draft Working Paper	D-3031	D-3031
JI 129	Reedy "QA Review and Audit Report, Phase I; Safety-Related Activities Performed by PG&E Prior to 6/78	D-1000	D-1000
JI 130	7/82 BNL "Independent Seismic Evaluation of the Diablo Containment Annulus Structure	D-2612	D-2612
JI 131	7/1/82 L:Denton-Cooper Re: BNL Findings on discrepancies in seismic design	D-2613	D-2613
JI 132	5/17/83 L:Reich-Kuo, BNL Findings Re: Analysis of Horizontal Response	D-2614	D-2614
JI 133	12/82 ITR 34, Draft	D-1793	D-1795
JI 134	5/16/83 Design Criteria Memorandum M-65, Rev. O		
JI 135	2/74 3.6 Criteria for Protection Against Dynamic Effects Associated with Postulated Rupture of Piping		
JI 136	12/18/72 L:Giambusso-Searls Re: Effects of a Piping System Break Outside Containment	D-651	D-651
JI 137	Summary and Evaluation Report ITR 9	D-2616	
JI 138	11/23/82 L"Cloud-Hoch	D-1759	D-1760
JI 139	9/21/83 L:Maneatis-Eisenhut Transmitting Comments on Draft of Case Study C	D-	D-
JI 140	Changes from Draft to Final Case Study		

NUMBER	DESCRIPTION	OFFERED	ADMITTED
	STAFF EXHIBITS		
Staff 36	SER Supplement 18	D-2465	D-2467
Staff 37	SER Supplement 19	D-2465	D-2467
Staff 40	11/15/82 L:Bishop-Crane transmits NRC Inspection Report 50-275/82-36	D-2465	D-2467
Staff 41	11/22/82 L:Bishop-Crane transmits NRC Inspection Report 50-275/82-36	D-2465	D-2467
Staff 42	1/10/83 L:Bishop-Crane transmits NRC Inspection Report 50-275/82-41 & 50-275/82-19	D-2465	D-2467
Staff 43	1/19/83 L:Bishop-Crane transmits NRC Inspection Report 50-275/82-42	D-2465	D-2467
Staff 44	5/11/83 L:Bishop-Crane transmits NRC Inspection Report 50-275/83-14 & 50-323/82-19	D-2465	D-2467
Staff 45	8/18/83 L:Bishop-Schuyler transmits NRC Inspection Report 50-275/83-27 & 50-323/83-19	D-2465	D-2467
Staff 46	8/3/83 L:Bishop-Schuyler transmits NRC Inspection Report 50-275/83-26	D-2465	D-2467
Staff 47	2/3/82 M:Herring-Miraglia NRC Trip Report	D-2465	D-2467
Staff 48	3/3/82 M:Herring-Miraglia NRC Trip Report	D-2465	D-2467
Staff 49	3/31/82 L:Sternberg-Crane Region V Inspection Report 50-275/82-02 & 50-323/82-02	D-2465	D-2467
Staff 50	5/27/82 L:Bishop-Crane Region V Inspection Report 50-275/82-17	D-2465	D-2467
Staff 51	6/29/82 L:Sternberg-Crane Region V Inspection Report 50-275/82-20 & 50-323/82-10	D-2465	D-2467
Staff 52	10/14/82 L:Bishop-Crane Region V Inspection Report 50-275/82-30 & 50-323/82-14	D-2465	D-2467
Staff 53	2/11/83 L:Bishop-Crane Region V Inspection Report 50-275/82-30 & 50-323/82-14	D-2465	D-2467
Staff 54	9/19/83 M:Eisenhut-Commissioners. Board Notification 83-135A: Case Study C	D-2910	D-2910
Staff 55	SER Supplement 16	D-2465	D-2467

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING APPEAL BOARD

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

CERTIFICATE OF SERVICE

I hereby certify that on this date I caused copies of the foregoing Proposed Findings of Fact and Conclusions of Law of Governor Deukmejian served on the following by U.S. Mail, first class (except for those persons marked with an asterisk ("*"), to whom the envelope was posted Express Mail), postage prepaid.

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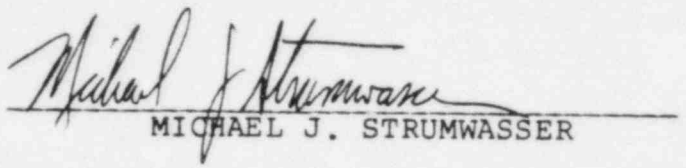
By 
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