UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING APPEAL BOARD

Richard S. Salzman, Chairman
Alan S. Rosenthal
Dr. W. Reed Johnson*

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

ORDER

November 19, 1979

In the proceeding below, intervenors' "security plan" contentions were handled apart from the rest of the case and intervenors were represented by separate counsel on these issues. They are continuing that practice on appeal. Their separate counsel filed a brief in support of their exceptions to Part IV of the decision below, which deals with their security plan contentions, on November 13, 1979. Under 10 C.F.R. §2.764, applicant's time to file a responding brief on this issue expires on December 18, 1979. To expedite this portion

* Dr. Johnson did not participate in this order.

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of the proceeding, we instruct the staff to file its own response on this issue by that same date.[1/]

It is so ORDERED.

FOR THE APPEAL BOARD

C. Jean Bishop
C. Jean Bishop
Secretary to the
Appeal Board

1/ We granted the motion of intervenors' counsel for the other issues for an extension until November 30, 1979, to file a brief on those issues.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

THE ATOMIC SAFETY AND LICENSING BOARD

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

ORDER RELATIVE TO THE PETITION
OF GOVERNOR EDMUND G. BROWN, JR.

On October 15, 1979, Governor Brown petitioned to intervene as a representative of an interested State under 10 CFR §2.715(c). On November 5, 1979, both PGandE and the NRC Staff responded to the petition. The Staff supported the Petitioner but requested that if the Petitioner is admitted that he be required to take "the hearings as he finds them as must all late Intervenors in an on-going proceeding." PGandE opposed the petition as grossly out-of-time, without good cause alleged for the late filing. PGandE also requested the Board, if Governor Brown was admitted, to require him to "state with specificity, and within fifteen (15) days of Petitioner's receipt of the Board's Order permitting such participation, the subject matters on which he desires to participate and the issues which he intends to raise." PGandE cited regulations, Appeal Board and Commission decisions to support its position that the issues he intends to raise should be stated. On November 9, 1979, the Joint Intervenors supported the

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intervention "for the reasons set forth in the NRC Staff's response on the same matter."

On November 15, 1979, a response to PGandE's filing was received from the Petitioner. The PGandE position on out-of-time filing is challenged as well as the request to identify issues within 15 days.

We need not belabor the point that Petitioner represents an interested State and while no reasons are stated for the late filing we do not believe this is reason to deny the petition in this proceeding.

The Board admits Edmund G. Brown, Jr., Governor of the State of California, to participate as representative of an interested State in this proceeding. The Intervenor will take the proceeding as he finds it.

In order for the participation of Governor Brown to be meaningful the other parties and the Board are entitled to know with some degree of specificity wherein his concerns lie. The parties are entitled to not be "surprised" and the Board needs to be apprised in order to determine if the issues are within its jurisdiction. We believe those issues can be identified within 30 days from receipt of this order and will expect to receive such a document or an appropriate motion.

IT IS SO ORDERED.

FOR THE ATOMIC SAFETY AND
LICENSING BOARD

Elizabeth S. Bowers

Elizabeth S. Bowers, Chairman

Dated at Bethesda, Maryland
this 16th day of November 1979.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the Matter of PACIFIC GAS AND ELECTRIC COMPANY (Diablo Canyon Nuclear Power Plant, Units 1 and 2)	)	Docket No.(s) 50-275 50-323

CERTIFICATE OF SERVICE

I hereby certify that I have this day served the foregoing document(s) upon each person designated on the official service list compiled by the Office of the Secretary of the Commission in this proceeding in accordance with the requirements of Section 2.712 of 10 CFR Part 2 - Rules of Practice, of the Nuclear Regulatory Commission's Rules and Regulations.

Dated at Washington, D.C. this
19th day of Nov 1979.

Peggy T. Downing
Office of the Secretary of the Commission

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
	)	
PACIFIC GAS AND ELECTRIC COMPANY	)	Docket No.(s) 50-275
	)	50-323
(Diablo Canyon, Units 1 and 2)	)	
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	)	
	)	

SERVICE LIST

Elizabeth S. Bowers, Esq., Chairman
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Mr. Glenn O. Bright
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dr. William E. Martin
Senior Ecologist
Battelle Memorial Institute
Columbus, Ohio 43201

Richard S. Salzman, Esq., Chairman
Atomic Safety and Licensing Appeal Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dr. W. Reed Johnson
Atomic Safety and Licensing Appeal Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Alan S. Rosenthal, Esq.
Atomic Safety and Licensing Appeal Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Counsel for NRC Staff
Office of the Executive Legal Director
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Pacific Gas & Electric Company
ATTN: Mr. John C. Morrissey
Vice President & General Counsel
77 Beale Street,
San Francisco, California 94106

Philip A. Crane, Jr., Esq.
Pacific Gas & Electric Company
77 Beale Street, Room 3127
San Francisco, California 94106

Mrs. Elizabeth Apfelberg
1415 Cozadero
San Luis Obispo, California 93401

Janice E. Kerr, Esq.
California Public Utilities Commission
5246 State Building
San Francisco, California 94102

Mrs. Raye Fleming
1920 Mattie Road
Shell Beach, California 93440

Mr. Frederick Eissler
Scenic Shoreline Preservation
Conference, Inc.
4623 More Mesa Drive
Santa Barbara, California 93105

Mrs. Sandra A. Silver
1760 Alisal Street
San Luis Obispo, California 93401

Mr. Gordon A. Silver
1760 Alisal Street
San Luis Obispo, California 93401

Paul C. Valentine, Esq.
321 Lytton Avenue
Palo Alto, California 94302

Yale I. Jones, Esq.
100 Van Ness Avenue, 19th Floor
San Francisco, California 94102

Brent Rushforth, Esq.
Stephen M. Kristovich, Esq.
Center for Law in the Public Interest
10203 Santa Monica Drive
Los Angeles, California 90067

David F. Fleischaker, Esq.
1735 I Street, N.W., Apt. 709
Washington, D.C. 20006

Arthur C. Gehr, Esq.
Snell & Wilmer
3100 Valley Center
Phoenix, Arizona 85073

Mr. James O. Schuyler
Nuclear Projects Engineer
Pacific Gas & Electric Company
77 Beale Street
San Francisco, California 94106

Bruce Norton, Esq.
3216 North Third Street, Suite 202
Phoenix, Arizona 85012

Mr. W. Andrew Baldwin, Esq.
Friends of the Earch
124 Spear
San Francisco, California 94105

Herbert H. Brown, Esq.
Hill, Christopher & Phillips, P.C.
1900 M Street, N.W.
Washington, D.C. 20036

Mr. J. Anthony Klein
Governor's Office
State Capitol
Sacramento, California 95814

Mr. Carl Neiburger
San Luis Obispo Telegram-Tribune
P.O. Box 112
San Luis Obispo, California 93406

Mr. James Hanchett
Public Affairs Officer, Region V
U.S. Nuclear Regulatory Commission
1990 N. California Boulevard, Suite 202
Walnut Creek, California 94596

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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Office of the Secretary Docketing & Service Section

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

ORDER

On November 14, 1979, the NRC staff filed a motion with the Commission requesting a six-day extension of time until Wednesday, November 21, 1979, in which to file its reply to Applicant's Motion for an Operating License. Pursuant to 10 CFR 2.772(b), this motion is granted and replies from all participants in this proceeding will be due on that date.

It is so ORDERED.

SAMUEL J. CHILK
Secretary of the Commission

Dated at Washington, D.C.
this 15th day of November, 1979.

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
	)	
PACIFIC GAS AND ELECTRIC COMPANY	)	Docket No.(s) 50-275
	)	50-323
(Diablo Canyon Nuclear Power Plant, Units 1 and 2)	)	

CERTIFICATE OF SERVICE

I hereby certify that I have this day served the foregoing document(s) upon each person designated on the official service list compiled by the Office of the Secretary of the Commission in this proceeding in accordance with the requirements of Section 2.712 of 10 CFR Part 2 - Rules of Practice, of the Nuclear Regulatory Commission's Rules and Regulations.

Dated at Washington, D.C. this
16th day of Nov 1979.

Peggy T. Downing
Office of the Secretary of the Commission

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the Matter of PACIFIC GAS AND ELECTRIC COMPANY (Diablo Canyon, Units 1 and 2)	)	Docket No.(s) 50-275 50-323

SERVICE LIST

Elizabeth S. Bowers, Esq., Chairman
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Mr. Glenn O. Bright
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dr. William E. Martin
Senior Ecologist
Battelle Memorial Institute
Columbus, Ohio 43201

Richard S. Salzman, Esq., Chairman
Atomic Safety and Licensing Appeal Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dr. W. Reed Johnson
Atomic Safety and Licensing Appeal Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Alan S. Rosenthal, Esq.
Atomic Safety and Licensing Appeal Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Counsel for NRC Staff
Office of the Executive Legal Director
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Pacific Gas & Electric Company
ATTN: Mr. John C. Morrissey
Vice President & General Counsel
77 Beale Street
San Francisco, California 94106

Philip A. Crane, Jr., Esq.
Pacific Gas & Electric Company
77 Beale Street, Room 3127
San Francisco, California 94106

Mrs. Elizabeth Apfelberg
1415 Cozadero
San Luis Obispo, California 93401

Janice E. Kerr, Esq.
California Public Utilities Commission
5246 State Building
San Francisco, California 94102

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1920 Mattie Road
Shell Beach, California 93440

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4623 More Mesa Drive
Santa Barbara, California 93105

Mrs. Sandra A. Silver
1760 Alisal Street
San Luis Obispo, California 93401

Mr. Gordon A. Silver
1760 Alisal Street
San Luis Obispo, California 93401

Paul C. Valentine, Esq.
321 Lytton Avenue
Palo Alto, California 94302

Yale I. Jones, Esq.
100 Van Ness Avenue, 19th Floor
San Francisco, California 94102

Brent Rushforth, Esq.
Stephen M. Kristovich, Esq.
Center for Law in the Public Interest
10203 Santa Monica Drive
Los Angeles, California 90067

David F. Fleischaker, Esq.
1735 I Street, N.W., Apt. 709
Washington, D.C. 20006

Arthur C. Gehr, Esq.
Snell & Wilmer
3100 Valley Center
Phoenix, Arizona 85073

Mr. James O. Schuyler
Nuclear Projects Engineer
Pacific Gas & Electric Company
77 Beale Street
San Francisco, California 94106

Bruce Norton, Esq.
3216 North Third Street, Suite 202
Phoenix, Arizona 85012

Mr. W. Andrew Baldwin, Esq.
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124 Spear
San Francisco, California 94105

Herbert H. Brown, Esq.
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1900 M Street, N.W.
Washington, D.C. 20036

Mr. J. Anthony Klein
Governor's Office
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San Luis Obispo, California 93406

Mr. James Hanchett
Public Affairs Officer, Region V
U.S. Nuclear Regulatory Commission
1990 N. California Boulevard, Suite 202
Walnut Creek, California 94596

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NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

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Glenn O. Bright, Member
William E. Martin, Member

DOCKETED USNRC SEP 28 1979 Office of the Secretary Docketing & Service Section

SERVED SEP 28 1979

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

September 27, 1979

PARTIAL INITIAL DECISION
(Operating Licensing Proceedings)

Appearances

For the Applicant, Pacific Gas & Electric

Bruce Norton, Esq., Arthur Gehr, Esq., Malcolm H. Furbush, Esq., and Philip Crane, Esq.

For the Joint Intervenors

Brent H. Rushforth, Esq., Simon Klevansky, Esq., Margaret Blodgett, Esq., and Stephen Kristovich, Esq., Center for Law in the Public Interest

David S. Fleischaker, Esq.

For the Nuclear Regulatory Commission

James R. Tourtellotte, Esq., Edward G. Ketchen, Esq., Marc R. Staenberg, Esq., Richard Goddard, Esq., and Lawrence Brenner, Esq.

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

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

I. PRELIMINARY STATEMENT

This Board assumed that it would be able to issue an Initial Decision following the hearings in December 1978, through February 1979. The last proposed finding it received was from the NRC Staff on April 10, 1979.

While the Board was reviewing the proposed findings in the wake of Three Mile Island-2 accident, on May 9, 1979, the Joint Intervenors filed a motion for the Board to reopen the evidentiary hearings in the light of TMI-2 or in the alternative to certify the questions to the Commission. The motion was supplemented by filings on May 10, 16 and 17, 1979.

On May 24, 1979, the Staff requested the Board to defer ruling on the motion pending completion of the Staff inquiry and report as to the effects of the TMI accident on the Diablo Canyon proceeding.

On June 1, 1979, Pacific Gas and Electric (PG&E) opposed the motion.

On June 5, 1979, the Board issued an order which stated that it will defer its ruling until it receives the Staff's report. The Board recognized that the Staff analysis would in fact be a Commission position on those issues which are TMI related. To date, that position has not been released. The Board has determined that only three issues can be considered in this Partial Initial Decision: seismic, potential aircraft or missile crashes into the plant, and the security plan. Other safety issues await the TMI analysis. Doubts about the validity of the radon issue record were raised by the Appeal Board in ALAB-562 on September 11, 1979.[1/] That issue will also be deferred.

The security plan issue has been considered under its special circumstances.

1/ Philadelphia Electric Company (Peach Bottom, Units 2 and 3), Metropolitan Edison Company (Three Mile Island Nuclear Station, Unit 2), Public Service Electric and Gas Co. (Hope Creek Generating Station, Units 1 and 2), Northern States Power Company (Minnesota) and (Wisconsin) (Tyrone Energy Park, Unit 1), Rochester Gas and Electric Corporation (Sterling Power Project, Nuclear Unit 1), ALAB-562, 9 NRC ___ (1979).

Introduction

On October 19, 1973, the Atomic Energy Commission issued the following notice in the Federal Register "Notice of Receipt of Application for Facility Operating Licenses; Notice of Consideration of Issuance of Facility Operating Licenses and Notice of Opportunity for Hearing." (38 Fed. Reg. 29105). The Notice related to the application of Pacific Gas and Electric Company (PG&E) for licenses to authorize the operation of the Diablo Canyon Nuclear Power Plant, Units 1 and 2 (the facility). The facility consists of two units located on the Pacific Ocean coastline in San Luis Obispo County, California. The units are manufactured by Westinghouse and are designed to operate at steady-state power levels of 3,338 and 3,411 megawatts thermal with a net total electric output of approximately 2,190 MWe.

On June 12, 1978, this Board issued a Partial Initial Decision relative to environmental issues based on an evidentiary hearing held December 7-10, and 13-17, 1976.[2/] That Partial Initial Decision is incorporated in this Partial Initial Decision. That document recites the background of this proceeding

2/ On November 17, 1976, Intervenors moved for reconsideration of their motion to add new contentions. At the environmental hearing the Board denied the motion in part (Tr. 1609-11). It did admit the following contention to be considered at the safety hearing: whether the final environmental statement adequately assesses all adverse environmental impacts that could occur from possible earthquake-caused accidents, including, but not limited to, Class 9 accidents, given the high potential seismicity of the Diablo Canyon site and the current design and construction of the Diablo Canyon nuclear plant. (See later stipulation.)

including identification and the history of the parties. In this hearing, the Board considered the somatic and genetic effects of radiation.[3/]

Due to the delay in being able to reach the seismic issues, the Board determined that it would proceed on the non-seismic health and safety issues with the exception of the security issue. An evidentiary hearing was held on October 18-19, 1977, on the following non-seismic issues: Emergency Planning, Quality Assurance, Probability of Aircraft Accidents at the Facility, and Revised Table S-3 values.[4/] The Board informed the parties that it might delay issuing a separate Partial Initial Decision on these issues but requested the parties to submit proposed findings so it would have the option to proceed with a second Partial Initial Decision, if the hearing on the seismic issues continued to be postponed.

The parties complied with this request but the Board determined it would not release another partial decision on these few issues since it appeared the hearing on the seismic issues could soon be scheduled. Part II of this Partial Initial Decision deals with the non-seismic safety issues which can be determined.

3/ Pacific Gas and Electric Company (Diablo Canyon Nuclear Power Plant, Units 1 and 2); LBP-78-19, 7 NRC 989 (1978). However, the Board deferred consideration of part of Intervenor's contention on the environmental effects of radiation releases due to seismic accidents until the safety hearing. The record was also specifically held open for receipt of the new S-3 generic table on the environmental effect of the fuel cycle when the Commission's interim rule is in place. (Tr. 1581, 1603-12).

4/ Table S-3 was further revised and the current version was admitted into evidence at the close of the seismic hearings as Staff Ex. 17 but, the issue is again deferred due to ALAB-562.

On April 24, 1978, the Board was informed by the Staff, on behalf of all parties, that the parties had agreed on the final language of the seismic issues. They also stipulated that the Staff's and Applicant's basic documents would be admitted into evidence. In order to clarify the the record, it was also stipulated during the hearing that amendments 50 et seq. to the FSAR (known as the Hosgri Report) would be admitted into evidence. (Tr. 6924-6926). For the purposes of reference the stipulated contentions are set out as follows:

> The seismic design for the category one structures, systems, and components of the Diablo Canyon nuclear power plant (Unit 1) fails to provide the margin of safety required by 10 CFR Part 50 and 10 CFR Part 100 in that:
>
> 1. The Applicant has failed to conduct investigations of the Hosgri Fault system to determine adequately (i) the length of the fault; (ii) the relationship of the fault to regional tectonic structures; and (iii) the nature, amount, and geologic history of displacements along the fault, including particularly the estimated amount of the maximum Quaternary displacement related to any one earthquake along the fault.
>
> 2. A 7.5 magnitude earthquake is not an appropriate value for the safe shutdown earthquake.
>
> 3. A .75g acceleration assigned to the safe shutdown earthquake is not an appropriate value for the maximum vibratory acceleration that could occur at the site.
>
> 4. The maximum vibratory acceleration of .2g for the operating basis earthquake is not 1/2 of the maximum vibratory acceleration of the safe shutdown earthquake.
>
> 5. The Applicant has failed to demonstrate, through the use of either appropriate dynamic analysis or qualification tests (or equivalent static load method where appropriate), that Category I structures,

systems, and components will perform as required during the seismic load of the safe shutdown earthquake, including aftershocks and applicable concurrent functional and accident-induced loads, and that Category I structures, systems and components will be adequate to assure:

a) the integrity of the reactor coolant pressure boundary,

b) the capability to shut down the reactor and maintain it in a safe condition, or

c) the capability to prevent or mitigate the consequences of accidents which could result in excessive offsite exposure.

6. The Applicant has failed to demonstrate, through the use of either appropriate dynamic analysis or qualification tests (or equivalent static load method where appropriate), that all structures, systems and components of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public will remain functional and within applicable stress and deformation limits when subjected to the effects of the vibratory motion of the operating basis earthquake in combination with normal operating loads.

7. The Applicant has failed to demonstrate adequately that necessary safety functions are maintained during the safe shutdown earthquake, where, in safety-related structures, systems and components, the design for strain limits is in excess of the yield strain.

When it became apparent after several years delay that the seismic issues could soon go to a hearing, the Board scheduled a conference of counsel for July 27, 1978. The Board ruled on various pending discovery matters and established a schedule for discovery. These rulings were confirmed by the Board's orders of August 3 and 7, 1978. In the conference, the Board advised the Joint Intervenors they would have two weeks if they wished to submit a contention on radon as part of the uranium fuel cycle (Tr. 3682). By letter of August 7, 1978, the Joint Intervenors stated they would not submit a contention on radon.

At the conference, all parties asked the Board to set aside only the first two days of the hearing for limited appearance statements since we had already heard approximately 200 limited appearance statements at prior proceedings. Their concern was based on the scheduling of their witnesses. The Board determined that this was a reasonable request and adopted it in its Order of August 7, 1978 and later confirmed it in the Order of November 7, 1978. Approximately 146 limited appearance statements were heard in the two days.

Following the first prehearing conference the Board's Order of May 30, 1974, admitted many contentions of the various Intervenors. Discovery commenced and was vigorously pursued by all parties. During the earlier years, the Intervenors were proceeding without counsel and limited technical assistance. Later when counsel and more experienced technical advisors were obtained, motions were filed for numerous new contentions. (See Joint Intervenors' proposed findings pp. 6-8). The Board considered each contention and when it determined there was no justification for the extremely late filing, denied the motion but later put the parties on notice that the Board would expect critical matters to be addressed e.g., quality assurance, generic safety issues.

The Joint Intervenors' proposed findings pp. 17-22 describe at length the matter of subpoenas issuing to two Advisory Committee on Reactor Safeguards (ACRS) consultants. That matter was settled by the Appeal Board decision of

January 23, 1979, the subpoenas were issued and Drs. Trifunac and Luco testified on February 7-9, 1979.[5/]

Following the completion of the review of the Staff and the ACRS, evidentiary hearings were held on the seismic issues on December 4-23, 1978, January 3-16, 1979 and February 7-15, 1979. Part III of this Partial Initial Decision pertains to the seismic issue. Part IV pertains to the security plan issue.

The record was closed at the end of the seismic hearing except for the generic safety issues and Table S-3 issues (Tr. 10,176 and 10,180).

Any proposed findings of fact or conclusions of law submitted by the parties, which are not incorporated directly or inferentially in this Partial Initial Decision, are herewith rejected as being unsupportable in law or in fact, or as being unnecessary to the rendering of the Partial Initial Decision.

5/ Pacific Gas and Electric Company (Diablo Canyon Nuclear Power Plant, Units 1 and 2), ALAB-519, 9 NRC 42 (1979).

II. FINDINGS OF FACT ON AIRCRAFT AND MISSILE ACCIDENTS

In the non-seismic issues hearing on October 18 and 19, 1977, four issues were heard: the Emergency Plan, Quality Assurance, Table S-3 and the probability and possible effect on Class I structures from aircraft and missile accidents. It is not now known how the Lessons Learned from Three Mile Island-2 will impact on the Emergency Plan or Quality Assurance so these matters will be deferred and are not a part of this Partial Initial Decision. The testimony on Table S-3 was updated as a separate matter at the conclusion of the seismic hearing but is now deferred due to ALAB-562. The only testimony from this segment of the proceeding holding firm is that concerning aircraft and missile accidents.

At the hearing the following exhibits were admitted into evidence:

FSAR, as amended	Applicant's Exhibit 5 (Tr. 3456)
Emergency Plan, including Appendices, Revision 1, September 1977	Applicant's Exhibit 6 (Tr. 3463)
Staff Safety Evaluation Report and Supplements	Staff's Exhibit 9 (Tr. 3460)

In addition, by stipulation, all of the prepared testimony of the witnesses was admitted into evidence to be inserted into the transcripts as if read (Tr. 3457-3458).

Aircraft Accidents

The Board requested the parties to address the question of the probability of aircraft and missile hazards at Diablo Canyon (Tr. 1307). The Applicant and the Staff each offered a witness on this issue.

Location

The Diablo Canyon Nuclear Power Station is located 12 miles from the nearest commercial airport (San Luis Obispo County) and approximately 5 miles from the closest approach of the nearest low level airway (V-27). Airway V-113 terminates at the San Luis Obispo VORTAC (an FAA radio navigational facility) 6.5 miles northeast of the plant site. The nearest high altitude airway is J-88, which passes 22 miles to the east. Operations in control area 1155 follow azimuth 226° to and from the San Luis Obispo VORTAC.

The nearest military low level training route is 21 miles to the north. The Hunter Military Operations Area (MOA) is 20 miles to the north. Operations to and from the ground occur in the restricted area 45 miles from the plant. The O'Sullivan Airfield, operated by the California National Guard, is located 10 miles northwest of the plant. Vandenberg Air Force Base (VAFB) and the Space and Missile Test Center (SAMTEC) are located 30 to 40 miles southeast of the plant.

Airport Operations

The San Luis Obispo County Airport is used only for general aviation operations, including air taxi service. The FAA estimate of 1976 operations is a total of 136,000 including 22,000 air taxi. These estimates are considerably larger than county estimates. The air taxi service employs primarily the NORD-262, a small twin-engine airliner, and the Heron, a comparably sized 4-engine plane. Of the remaining operations, approximately 90% involve single-engine aircraft and 10% light twin-engine aircraft. Approximately 40% of total operations are touch and go operations where the aircraft remain within the immediate vicinity of the airport. Discussions with airport personnel indicate that operations toward the plant site are severely limited by terrain considerations and lack of a need to pass through the area to travel to suitable flying areas.

The O'Sullivan field is operated by the California Air National Guard for training. It has a single 2400' paved runway. The largest fixed-wing aircraft is the twin-engine U-8 (Beechcraft Queen Air). The largest helicopter is the Boeing Vertol CH-47. The total number of operations is estimated, at present, to be less than 200 per year. Because of the low number of operations at O'Sullivan, it does not contribute significantly to potential hazards at the plant.

The next nearest airfield is the private Weir strip, which is 15 miles from the plant. It has a single 2,000-foot dirt strip and operations from it are no hazard to the plant.

The Oceano County Airport is located 16 miles from the plant. Operations are estimated to total 12,500 per year, all involving general aviation single-engine or light twin-engine aircraft. Considering the low usage and light aircraft operated, operations from Oceano County Airport do not contribute significantly to potential hazard at the nuclear plant.

All other airports in the area are sufficiently distant that they do not contribute significantly to potential plant hazards.

Airway Operations

The low level airways (V-27 and V-113) are for aircraft operations below 18,000 feet. Aircraft operating along these airways will include local air carrier and air taxi operations and general aviation aircraft flying under instrument flight rules. The FAA's Los Angeles Air Route Traffic Control Center (ARTCC) has indicated that the 1977 peak day IFR operations along the airways near the plant were 44. In addition, 31 take-offs or landings at San Luis Obispo were handled, along with 8 direct flights from VAFB. Information from VAFB indicates that an additional 30 military aircraft flew from VAFB to the San Luis Obispo VORTAC. A conservative estimate of peak day operations along airways adjacent to the plant is the sum of these or 113 per day. For the Los Angeles region, the annual average daily traffic is 73% of the peak day traffic.

High altitude airways are for aircraft operation at 18,000 feet and above, and are used primarily by air carriers. As indicated previously, J-88 is located 22 miles away from the plant. At this distance, it poses no credible hazard to the plant. The 1976 peak day charts show 21 direct flights (not along the airway) going directly over the San Luis Obispo VORTAC.

Control area 1155 is an alternate route for air carrier flights to and from the Pacific. This route is used periodically when missile operations from VAFB interfere with the normal routes to Los Angeles further south. LA ARTCC personnel estimate the number of flights to use this area is on the order of 200 per year. When passing over the San Luis Obispo VORTAC, the aircraft are at altitude of 28,000 feet or more.

Missile Launch Activities

The Air Force Space and Missile Test Center operations include test and training launches of weapons systems and military and non-military satellite launches. Space shuttle launches may also originate from SAMTEC. Most launches from SAMTEC are in the southwest quadrant. Polar orbit is achieved by a southerly launch. Very few launches are north of 270°. The Diablo Canyon site is located at an azimuth of approximately 327° from the northern most launch area.

In order to minimize the risk to facilities and populations, the flight of a vehicle is terminated (aborted) if it should deviate from its planned flight path and an inhabited area be threatened. In establishing the location where missile destruct would be required (the abort line) time delays in instruments and controller responses, possible missile performance deviations and 90 percentile wind conditions are considered.

SAMTEC personnel estimate that the probability of any debris impacting the Diablo Canyon site would be less than 10^{-9} for launches at the extreme northern limit of allowable launch azimuths. As indicated previously, very few flights would be expected in this direction.

Applicant's witness, E. Robert Schmidt testified initially that the combined hazards posed by aviation resulted in a probability of aircraft impact upon the plants of 0.8×10^{-7} impacts per year, using appropriately conservative estimates (Tr. 3629; Schmidt Testimony following Tr. 3458, at 8), with the overall probability of exceeding 10 CFR 100 radiation release guidelines due to aircraft accident ranging from 10^{-9} to 10^{-10} per year. (Id. at 9). On cross-examination, however, the witness testified that elimination of the conservative aspects of his estimates would give rise to a "true potential crash rate, best estimate--if you will--of a crash rate into the plant would be 10^{-10}, in that neighborhood." Tr. 3643. Staff's witness, Harry E. P. Krug, Accident Analysis Branch, NRC, concluded that the lifetime average (conservative strike probability) would approximate 1.8×10^{-10} impacts per year--well below the values set forth in the Staff's Standard Review Plan and 10 CFR Part 100. (Krug Testimony, following Tr. 3649 at 8-10).

In light of the requirement set forth in <u>Atlantic City Electric Co.</u> (Hope Creek Generating Station, Units 1 and 2), ALAB-429, 6 NRC 229 (1977) for licensing boards to justify choices between conflicting pieces of testimony, the following points are noted: The Staff's Safety Evaluation Report considered the proximity of nearby industrial and military facilities, including the nearest airport and Vandenberg Air Force Base and concluded that due to the lack of such industrial and military facilities in the area of the plant, safe operation would not be adversely affected. Both witnesses testifying on this contention were familiar with nuclear power plant licensing requirements and considered the risk from aircraft crashes to be acceptably low. The differences in their numerical results can be ascribed to differing assumptions made in their calculations. Mr. Schmidt has no practical experience in the field of aviation, compiled his estimates from published statistics alone, was not familiar with FAA categorization or pilot skill levels of Swift Aire Lines, the major commercial user of San Luis Obispo County Airport, and had not viewed the facility and its site from the air, all matters which could be assigned <u>some</u> valuation in reaching a "best estimate." Conversely, Mr. Krug testified that in addition to having an appropriate background in science and mathematics, he is a commercial pilot, instrument rated, single-engine land and sea, multi-engine rated, was familiar with Swift Aire's flight routes, pilot qualifications, and aircraft types, and that he had overflown the plant. (Tr. 3651-57). He also demonstrated considerable knowledge of the Federal Aviation Regulations and their requirements with regard to overflights of major structures (Tr. 3653-55).

The Board finds that a reasonable probability of an aircraft accident impacting upon the plant is approximately 1.8×10^{-10} impacts per year, well below the requirements of 10 CFR Part 100 in regard to accidental radiation releases.

Based on the detailed survey of aircraft and missile operations in the vicinity of the Diablo Canyon plant and on the evaluation of potential hazards of these operations, the Board finds that aircraft and missile operations do not present an undue risk to the public health and safety at the Diablo Canyon Nuclear Power Station.

III. FINDINGS OF FACT ON SEISMIC ISSUES

In general terms the issues raised by the contentions all relate back to the ability of the Diablo Canyon Nuclear Power Plant to withstand any earthquake that can reasonably be expected to occur on the Hosgri fault, which is located approximately three miles from the site.

Thus the primary issues can be classified for simplicity as follows:

1) What is the maximum credible earthquake that can reasonably be expected to occur on the Hosgri fault at its nearest point to the plant?

2) What vibratory ground motion will that produce at the plant?

3) What criteria for evaluation of the plant for the postulated Hosgri event are proper?

4) How will the plant structures, components and equipment respond to that vibratory ground motion?

BOARD EXHIBITS

EXHIBIT NO.		IN EVIDENCE
1	Willingham illustration of CDP System	4622
2A-I	Trifunac/Luco documents identified on Tr. 4286-8 and 4355	9012
2J	Anderson-Trifunac Report "Uniform Risk Absolute Acceleration Spectra for the Diablo Canyon Site"	9012
3*	Weber and Lajoie Figure re Slip on San Gregorio Fault	
3	"Earthquakes, A Primer" by Bruce Bolt	

*Renumbered JI Exhibit 32.

EXHIBIT NO.		IN EVIDENCE
4	Article "Rational Determination of the Operational Basis Earthquake and its impact on Overall Safety and Cost of Nuclear Facilities" by J. D. Stevenson, Sept. 1975	

PGandE EXHIBITS

7	PGandE Witness' Technical Qualification	4388
8	Slide: Gualala Basin to Eagle Rest Peak	4417
9-29	Photographs of San Francisco Buildings	6084
30	Geological Society of America Abstract (Silver)	6301
31	Interpretation of Preliminary Gravity Map	6301
32	Blowup of Box-end on Ex. 31	6301
33	Open File Report 75-121 (USGS-1975)	6301
34	USGS Bathymetric Profile	6301
35	Frazier - Q Attenuation	6855
A	Operating License Application and All Amendents and Supporting Material	6926
36	Brune Drawing	8114
37	California Division of Mines and Geology Map (same as J.I. 35)	8144
38	Report by T. W. Pickel to ACRS 5/31/78	
39	Report by G. A. Thompson to ACRS 11/21/77	
40	Page Memo to Siess	
41	Thompson Letter to McKinley 7/22/77	

EXHIBIT NO.		IN EVIDENCE
42	Hall diagram of faults	9698
43	J.I. 107 modified	9698
44	J.I. 107 with hatch marks	9698
45	Fugro Report	9698
46-60	Slides - Geology Panel Rebuttal	10,100
61	Peak acceleration as a function of M (slide)	10,161
62	Near Field Strong Motion Records Not Included in Hanks and Johnson data (slide)	10,161
63	Peak Horizontal Accelerations Recorded in Naghan, Pacoima, Koyna and Gazli Earthquakes (slide)	10,161
64	Seed drawing of waves (slide)	10,161
65	Seed drawings showing earth heterogeneities	10,172

INTERVENOR EXHIBITS

14	Jahns sketch - en echelon - anastomosing faulting	4621
15	Jahns sketch - strike-slip and normal faulting	4621
16	Location of Transition Zone with ten mile boundaries approximated	
17	Map from Fugro Report - Plate 1	4813
18	Hoskins-Griffiths Map of Santa Cruz and Bodega Basins (slide)	5000
19	Stratigraphic Columsn - Pt. Reyes and Santa Cruz Regions (slide)	5011
20	Bathymetric Map - Monterey Submarine Canyon (slide)	5026
21	Map - Basement Contours in Monterey Bay Region (slide)	5026

22	Regional Geology Along San Gregorio Fault Area (slide)	5046
23	Graham-Dickenson Map of Faults at South End of San Gregorio Fault Zone (slide)	5046
24	Complete Bouguer Anomaly Map (slide)	5046
25	Map of Coast from Pfeiffer Point and Saboranes Pt. (slide)	5046
26	View Northwest from Hurricane Point (slide)	5046
27	View of Santa Margarita Formation at Hurricane Point (slide)	5046
28	View Down from Hurricane Pt. to Seacliff (slide)	5046
29	Detailed View of Marble and Schist Fragments (slide)	5046
30	View of Sheared Sur Series Schist (slide)	5046
31	Abstract, 1977 Presentation by Weber and Lajoie	
32	Weber and Lajoie Figure re Slip on San Gregorio (formerly Board Ex. 3)	
33	Graham and Dickenson Science Article	5236
34	Map of Magnetic Intensity - Pigeon Point and Pt. Arena (slide)	5236
35	Map from CDMG Report by Hall - Location of San Simeon-Hosgri Fault Zone (slide)	5236
36	Hall Article from Science Magazine re San Simeon-Hosgri Fault System	9595
37	Hall Article CDM Bulletin re Lompoc-Santa Maria Pull-apart	9595
38	Complaint in U.S. District Court - D. C. Cir.	
39	Smith Diagram - Illustrations of Seismograms (slide)	5613
40	Smith equation (slide)	5613
41	Bolt - Focal Mechanism of Earthquakes (slide)	5613

Intervenor Exhibits (continued)

42	Bolt - Sample Fault Plane Solutions (slide)	5635
43	Bolt - Sample Epicentral Locations (slide)	5635
44	Pages from FSAR 2.5(e)	
45	USGS Bulletin 672	8680
46	USGS Open File Report 509 re Ground Motion Parameters	
47	Hanks and Johnson Paper "Geophysical Assessment of Peak Accelerations	5944
48	Graham Testimony	6148
49	Silver Testimony	6148
50	Map from Bolt's Book	6153
51	USGS Map MF-910, sheet 1	6227
52	USGS Map MF-910, sheet 2	6227
53	Example of Determination of Acceleration Response Spectrum	6693
54	Determination of Normalized Acceleration Response Spectrum	6693
55	Frazier - Response Spectrum Equation	6693
56	Malik Letter to Hoch 7/20/78 w/att.	6836
57	Gangloff Letter to Kelley 5/30/78 w/att.	6836
58	"Analysis of Soil Structure Interaction Effects During Earthquake of Diablo Canyon Nuclear Power Plant" by Seed and Lysmer	
59	Malik Letter to Hoch 5/16/78	6836
60	Blume draft "Effect of Prior Loading of Reinforced Concrete on its Damping Value"	

Intervenor Exhibits (continued)

61	Drill Hole Log	
62	Slide: Containment Shell Diagonal Reinforcing Stress	7052
63	Table: Containment Shall Diagonal Reinforcing Stresses	7052
64	Memo: Document PD 608	
65	Hubbard Testimony and Qualifications	7895
66	Brune Testimony and Qualifications	7940
67	Note: DeYoung to Giambusso 2/20/75	
68	Memo: Program to Establish Basis to License Diablo Canyon 1/12/76	
69	Note: DeYoung to Giambusso 2/11/75	
70	Memo: Fraley to Rusche 12/20/76	
G & H	Previously Board Exhibits 2G and 2H	8403
71	Draft Report "Response Spectra of Combined Translation and Torsion For a Traveling Seismic Wave" by Newmark, et al.	
72	Clarence Hall Bibliography	9470
73-106	Set of Slides by Clarence Hall	9700
107	Generalized Fault Map, West Central California	9596
108	Map from California Division of Mines and Geology Special Report 137, Fig. 1	9596
109	Abstract of Fugro Report from Transactions, American Geophysical Union	9698
110	USGS Open File Report 79-385 "San Gregorio-Hosgri Fault Zone, A Reduced Estimate of Maximum Displacement" by V. Seiders, January 1979	

STAFF EXHIBITS*

EXHIBIT NO.		IN EVIDENCE
10	Equation Nine, NB-3652	
11	NUREG-0371, Task Action Plans for Generic Activities	
12	NUREG-0471, Generic Task Problem Descriptions, Categories B, C and D Tasks	
13	Technical Qualifications - Michael B. Aycock	
14	Technical Qualifications - Lawrence P. Crocker	
15	Affidavit of Aycock, Crocker and Allison re Generic Safety Issues	
16	Affidavit of Allison and Thadani Relating to ATWS	
17	NRC Staff Motion Re Radon Testimony and Perkins Record	

* Exhibits 11-17 were accepted by the Board's Orders of February 26 and March 12, 1979. These exhibits pertain to matters outside this Partial Initial Decision.

A. Geologic Setting of the Site

CONTENTION 1

> The Applicant has failed to conduct investigations of the Hosgri Fault system to determine adequately (i) the length of the fault; (ii) the relationship of the fault to regional tectonic structures; and (iii) the nature, amount, and geologic history of displacements along the fault, including particularly the estimated amount of the maximum Quaternary displacement related to any one earthquake along the fault.

The significance of this contention lies in the fact that the length, nature and seismic and geologic history of a fault are the basic parameters used by geoscientists in arriving at the maximum credible earthquake that the fault might be capable of. A great deal of evidence on this point was presented by all parties during the extended hearing. The Board notes, however, that in the separate findings submitted by the parties that they all agree that a 7.5 M value is conservative, and that there is thus no issue here for either Contention 1 or Contention 2. The Board will delineate, however, what we believe to be the pertinent evidence with the objectives of both showing why the Board agrees with the parties, and to provide a better understanding of the case when considering later contentions.

Geologic Setting of the Site

PG&E witnesses Douglas Hamilton, Dr. Richard H. Jahns, and C. Richard Willingham presented detailed testimony concerning the geologic and seismologic setting of the Diablo Canyon Power Plant. (Applicant's Testimony following Tr. 4457). In their testimony they pointed out that the Diablo Canyon site is located along the southwest-facing coast of the mountainous peninsula that lies between San Luis Obispo Bay and Estero Bay, within the Southern Coast Ranges structural province of California. The terrace at the site is underlain by sedimentary rocks, chiefly sandstone and siltstone, approximately 16 million years old. Prior to project construction, these rocks were overlain by an unfaulted sequence of sand, clayey sand, gravel, and rubble, all of the Pleistocene age and probably between 80 and 120 thousand years old (Testimony at 1).

During the approximately 200 years of historic record, the interior of the Southern Coast Ranges province has exhibited a moderate level of seismic activity, with scattered earthquakes ranging up to a maximum of magnitude 6. In geologic terms the period of historical record is brief, but evidence that surface displacements along major faults in the province have been minor or non-existent indicates that this pattern of small to moderate earthquakes has characterized most of the province during the past 100,000 years or more. (Testimony at 2, 3).

With respect to seismic considerations, the principal structural feature in California is the San Andreas Fault, which extends about 800 miles from Cape Mendocino to the Gulf of California. It is the boundary between two major tectonic plates of the earth's crust, and the North American Plate and the Pacific Plate and the cumulative slip along this break over the past twenty-two million years amounts to about 190 miles. (Testimony at 3, 5). The great bulk of interplate movement between these plates has occurred along the San Andreas Fault. (Tr. 4876). Movement along this fault over the past twenty-two million years has been predominately strike-slip or horizontal. (Testimony at 6).

Tectonic activity in the area is predominantly concentrated along the San Andreas Fault. In the main southern part of the Coast Ranges province, no other faults show evidence of more than minor seismic activity during Holocene time (the last 10,000 years). The same is generally true of the adjacent offshore region where both the sea floor and the unconformity at the base of the Post-Wisconsinan sea floor deposits provide useful datum surfaces for gauging Holocene deformation down to about 350 feet of depth. (Testimony at 18).

The Southern Coast Ranges tectonic province is characterized by faults with northwesterly trends and typically right-lateral or high-angle senses of movement. The larger faults, which may be regarded as second-order features relative to the San Andreas, are 50 to 100 miles long. Most of the larger faults have records of historic seismicity with a range from small shocks up to earthquakes of about 6.0 magnitude, but expressions of Holocene surface displacements are characteristically lacking.

The geologic relationships at the Diablo Canyon site have been studied extensively in terms of both local and regional stratigraphy and structure, with an emphasis on relationships that could aid in dating the youngest tectonic activity in the area. Geologic conditions that could affect the design, construction, and performance of various components of the plant installation also were identified and evaluated. The investigation included extensive mapping and trenching of the site. (Testimony at 90-95).

The Hosgri Fault

Evaluation of the site prior to the issuance of construction permits in 1968 and 1970 established that it is in an area of relatively low seismicity. The controlling faults were considered to be the San Andreas, 48 miles northeast, the Nacimiento, 20 miles northeast, and the Santa Ynez, 50 miles to the south. For design purposes, maximum probable earthquakes were postulated to occur on these faults, and, in addition, the possible occurrence of a 6.75M earthquake anywhere in the area, including directly under the site, was postulated. Because of the absence of seismic activity that would indicate a nearby significant fault, plus the assumption of a large earthquake which might occur anywhere in the area, offshore exploration did not seem to be necessary. (Tr. 6461).

Subsequent to the issuance of the construction permits, studies of the offshore area were published: Hoskins and Griffiths in 1971 and Wagner in 1974. The Hoskins' and Griffiths' paper gives the results of an interpretation of extensive deep penetration seismic reflection surveys along the California coast. The surveys revealed a structural basin offshore of the Southern Coast Ranges which is called the Santa Maria Basin. It is described as being a shallow synclinorium about 140 miles long and 25 to 30 miles wide. Structural grain within the basin trends northwest parallel to the trend of the basin. Major faults bound the basin on both the east and west. The eastern border fault, now known as the Hosgri Fault after Hoskins and Griffiths, passes within about five miles of the Diablo Canyon site. (Testimony of Dr. J. Carl Stepp [Stepp Testimony], following Tr. 8484, at 2, 3).

Wagner utilized both deep penetration seismic reflection methods and high resolution seismic surveys. The configuration of the sea floor was obtained by using precision bathymetric measurements and, locally, by side-scan sonar. These techniques provided a considerable refinement of the structures along the eastern boundary of the Santa Maria Basin in the region between Cape San Martin and Point Sal. He indicates that the basin formed in Middle-to-Post-Miocene (post 26 M. Yrs.) time. It contains from 2,000 to 5,000 feet of Miocene sediments, unconformable, overlain by up to 3,500 feet of Pliocene (7 M.Y.) section. An erosion surface is indicated to have formed on these Tertiary beds during Pleistocene time. Post-Wisconsinan age sediments, deposited during the past 20,000 years, overlie much of the Tertiary erosion surface. Wagner concurred with the interpretation of Hoskins and Griffiths that a major fault zone forms the eastern boundary of the Santa Maria Basin. This fault, the Hosgri, is a zone containing from 2 to 5 subparallel fault splays which locally offset Tertiary and Pre-Tertiary rocks with apparent vertical displacements ranging between 1,500 feet and 6,000 feet. The fault is discontinuous and segmented in the late Tertiary and Quaternary section. (Stepp Testimony 3, 4).

Subsequent to the discovery of the Hosgri Fault, the Applicant conducted extensive high resolution investigations of the structure, as did the USGS somewhat later. (Stepp Testimony at 8, 9). The methods utilized include several types of seismic or acoustic reflection profiling systems, as well as mapping of the earth's gravitational and magnetic fields in the region traversed by the fault. (Applicant's Testimony at 111). All in all, approximately 9,000 miles of lines of profiles in the offshore area of the Hosgri Fault Zone were reviewed in Applicant's analysis of the Hosgri Fault. (Tr. 5411).

Applicant presented a detailed description of its evaluation of the Hosgri Fault. (Applicant's Testimony, 106-131). Briefly, their analysis shows that the Hosgri Fault zone is present in the area offshore from the coast of south-central California, where it extends for a distance of about 90 miles (145 kilometers) between end points near Purisima Point on the south and near Cape San Martin on the north. (Applicant's Testimony at 106; Tr. 4418, 4859). It is a part of the San Gregorio-San Simeon-Hosgri fault system. (Tr. 4645). The fault zone is part of the Coastal Boundary zone, which is a boundary feature between the uplift of the Southern Coast ranges and the structural depression of the adjacent offshore Santa Maria and Sur Basins. (Applicant's Testimony at 107). The Hosgri Fault underlies the sea floor at water depths ranging from 150 to 500 feet. The generally featureless character of the sea floor along the Hosgri Fault trace precludes the possibility of either large-scale or recurrent surface offsets along it during the last 10,000 to 17,000 years. (Applicant's Testimony at 108; Tr. 5333, 5335). The principal sense of movement along this fault is strike-slip, although it has a dip-slip component, and both probably are significant. (Tr. 5315). It is not the kind of fault upon which one would expect a great earthquake, because it is too small and what can be observed of it does not indicate a past occurrence of major cumulative slip, at least during the last five million years. (Tr. 5315). Perhaps most important, its current role in the regional tectonic situation is such that it is not a major feature. The differential drift between the two principal plates involved in the area (Pacific and North American) is about six centimeters a year, most of which can be accounted for by movement along the San Andreas and Rinconada Faults, leaving very little for other faults. (Tr. 5315, 5316).

The Hosgri Fault has dimensions that equal those of some second-order faults; however, no record of its behavior during early and middle Pleistocene time (10,000 to 2-1/2 M.Y. before present) remains owing to successive episodes of marine planation of the rocks within which it is developed. Consequently, it has not been possible to determine whether it should be regarded as a small second-order or a large third-order fault. (Applicant's Testimony at 20, 21; Tr. 4422, 4423, 4646). However, there is enough evidence of late-Pleistocene (the last 500,000 years) movement to conclude it is prudent to consider the Hosgri to be a capable fault, within the meaning of 10 CFR 100, Appendix A of the Nuclear Regulatory Commission's Regulations.

With the preceding as background, we now turn to consideration of the subparts of Contention 1. Subparts (i) and (ii) will be considered together, as we believe there is a functional relationship between them.

> C. ... (i) the length of the fault; (ii) the relationship of the fault to regional tectonic structures.

The issue at bar here is basically that of fault length, as this is an important parameter in determining how high the magnitude of an earthquake on the fault can be. Applicant's analysis of the available data shows that the main or central reach of the Hosgri Fault extends over a distance of about

60 miles, between the approximate latitudes of Point Sal on the south and Cambria on the north. Beyond this reach the fault extends about ten miles further south and about 20 miles further north to give a total length of about 90 miles. (Applicant's Testimony at 115-120). As noted, *supra*, the Hosgri Fault is a part of the Hosgri-San Simeon-San Gregorio Fault Zone, and the question is whether these three faults are connected, thus forming a single fault capable of sustaining a much more energetic earthquake than the Hosgri Fault alone.

On the north, the Hosgri Fault zone can be traced for about 30 miles north of Estero Bay where it lies *en echelon* with the San Simeon Fault. (Stepp Testimony, at 16-19, Tr. 4871-4873). The Hosgri Fault and the San Simeon Fault are not connected. Seismic reflection lines that cross the Hosgri Fault between Point Estero and Point San Simeon do not show any major branches of the Hosgri extending toward the projected southerly extension of the San Simeon Fault. These reflection lines show that the contact between late Tertiary (2.5M.Y. to 16 M.Y. ago) rocks and basement rocks that approximately parallels the shore line between Point Estero and Point San Simeon is not displaced as it should be if offset by major vertical or lateral faulting. A shale that lies along the southwest side of the San Simeon Fault at San Simeon Point can be traced to the southeast indicating the San Simeon Fault does not veer toward the Hosgri in that reach.

The Hosgri Fault dies out north of Point Piedras Blancas. It does not veer toward the San Simeon Fault but instead gradually dies out along a trend that is subparallel to that of the San Simeon Fault.

Additional evidence precluding the possibility of a link between the Hosgri Fault and the San Simeon is provided by the aeromagnetic map of the Point Estero-San Simeon region. This map indicates that a block of basement rocks extends unbroken between the Hosgri and the San Simeon Faults in the area that would contain any linking break that could permit through-going transfer of slip from one fault to the other. The magnetic anomaly pattern indicates that no such break exists, and therefore, we conclude that the Hosgri and San Simeon Faults are distinct, unconnected breaks. (Applicant's Testimony at 120-123; Tr. 4422, 4923-4926). Both Staff and Applicant testified that the Hosgri and San Gregorio are not linked to form one fault. The San Simeon and Hosgri Faults form the eastern boundary of the Santa Maria Basin. Hoskins and Griffiths (1971) map the northern boundary of the Santa Maria Basin as being the west-northwest trending Point Sur antiform and the Pfeiffer Fault. The San Simeon Fault either veers to the west-northwest or continues as the Point Sur Fault. The Point Sur Fault is mapped as a thrust fault while the San Simeon displays predominantly normal movement. (Stepp Testimony, pp. 19-20).

The U. S. Geological Survey concluded that offshore faults north of Point Piedro Blancas (an area of possible linkage between the San Simeon and San Gregorio Faults) do not form a single continuous fault. The USGS states that the San Simeon Fault is projected northwest immediately offshore and is truncated by the Sur Nacimiento Fault Zone. (SER Supp. 4, App. C). The Hosgri Fault terminates in folding in this region or trends more westerly. (Ibid.)

The Hosgri and San Simeon Fault zones belong to the same coastal zone of deformation. The style of tectonism within the coastal deformation zone is one of anastomosing and en echelon faults, which is typical of other fault systems within the Coast Range that are subsidiary to the San Andreas. The Hosgri Fault and the Sam Simeon Fault approach as close to each other as 2-1/2 miles north of Estero Bay. However, substantial geologic data leads us to conclude that they are not directly linked. (Stepp Testimony at 17-19). Thus from the preponderance of available geologic evidence, we conclude that the relationship between the Hosgri, San Simeon, and San Gregorio Fault zone is one of an en echelon or anastomosing series of faults, which is typical of fault systems in the Coast Ranges, and not a continuous plate margin master break like the San Andreas. (Ibid., at 19-20, 22).

On the Hosgri Fault to the south from about the latitude of Point Sal southward, the Hosgri Fault progressively loses definition as a separate major break and dies out within a zone of complex folding and faulting that generally characterizes this region. This interpretation is supported by the original Shell Oil Company map of the fault published by Hoskins and Griffiths and the most recent USGS map. (Applicant's Testimony at 123-125; PG&E Ex. 45, p. 14; Tr. 4874, 4875).

The Hosgri Fault forms the southerly part of the Coastal Boundary zone of features and faults that lie between the uplift of the Southern Coast Ranges and the structural depression of the offshore basins. It either terminates or passes into the Transverse Range structure. This interpretation is consistent with mapped Coast Ranges structures in the region where they intersect Transverse Range structures. (Stepp Testimony at 16, 12-16, 21).

Because of its location at the south end of the Coast Ranges, the southernmost end of the Hosgri Fault extends into the region of transition ("Transition Zone") from the Southern Coast Ranges region into the Transverse Ranges structures. The Transverse Ranges, including the region of transition is one of active compression and is the area in the vicinity of which large earthquakes are more likely to occur than in the Coast Ranges region. (Tr. 4660, 4661, 4666, 4736). In other words, the Hosgri Fault Zone is to be contrasted, in terms of tectonic setting and earthquake capabilities, with the Transverse Ranges and the Applicant's Transition Zone. (Tr. 4419).

The overall structural relationships of the Hosgri can be generalized into three regions, each characterized by a particular set of relationships. These include, first, the northerly region where strain is transferred across the Piedras Blancas antiform between the Hosgri Fault and the next major member of the Coastal Boundary zone to the north, the San Simeon Fault. The second region is the central region where west-northwesterly trending folds and faults in the uplifted ground east of the Hosgri are detached across it from north-northwesterly folds in the downdropped basin on its west side. Last is the southerly region when the Hosgri enters and dies within the region of merging between the Southern Coast Ranges and the Western Transverse Ranges. (Applicant's Testimony at 125-128).

The entire length of the Hosgri Fault zone has been surveyed by intermediate and high-resolution systems. The results of this exploration show that both the sea-floor and the wave-cut rock surface beneath the post-Wisconsinan (17,000 years ago and younger) surficial deposits are unbroken along most survey lines south of San Luis Obispo Bay. A recent survey commissioned by and conducted for the USGS by Fugro, Inc. (PG&E Exhibit 45) shows offset of the base of the post-Wisconsinan deposits along a short reach of the Hosgri Fault south of Pt. Sal. That survey concludes, however, that the Hosgri Fault probably terminates about the latitude of Purisima Point. (Applicant's Testimony at 128-131; Tr. 4688, 4689-4693, 4809-4810, 4816-4818, 4822-4832, 4836-4837, 4839; Tr. 8264-8265).

Geological evidence was presented by Intervenor's witnesses, Dr. Stephan A. Graham and Dr. Eli A. Silver, concerning the length of an assumed continuous San Gregorio-San Simeon-Hosgri Fault, the amount of right lateral slip which occurred on the hypothetical continuous fault, and the maximum size of the earthquake to be expected on such a feature. (Joint Intervenors ("J.I.") Exhibits 48 (Graham) and 49 (Silver); admitted Tr. 6148).

According to Dr. Graham, in theory, between five and fifteen million years ago the Hosgri-San Gregorio Fault system was a continuous feature, a key element of the plate boundary between the Pacific and North American plates.

Dr. Graham's theory, however, was based upon a limited amount of field work, (Tr. 6233) and depends upon the matching of seven pairs of geological features on the eastern and western sides of the three faults (viz, the San Gregorio, the San Simeon, and the Hosgri).

Material evidence in the record demonstrates, based on geological field work at all but one of the stated locations, that it is extremely doubtful that the seven pairs of features or offset points developed by Dr. Graham do indeed match. (Tr. 5166-5197). Dr. Graham expressed no opinion as to the present continuity of the San Gregorio-Hosgri Fault system, or the capability of the Hosgri Fault today. (Tr. 6233).

With respect to Dr. Silver's argument that the Hosgri and San Gregorio Faults are connected, in addition to extensive other evidence in the record showing that the Hosgri and San Gregorio Faults are not connected (Stepp Testimony at 11, 17-20, 22) certain aeromagnetic studies of the area generally thought to be the location of any possible connection between the two faults showed that in fact the two faults are separated by an intact mass of Franciscan bedrock that is several kilometers in width. (Tr. 10,017-10,020).

Joint Intervenors presented as a rebuttal witness Dr. Clarence A. Hall. Dr. Hall testified that the Hosgri and San Simeon Faults join at depth (Tr. 9530). He postulates a continuous fault beginning at the juncture of the San Gregorio and San Andreas Faults north of San Francisco, continuing through the San Simeon, down through the Hosgri. He also postulates a landfall of the

Hosgri between Purisima Point and Point Arguello, extending then to the Lompoc-Solvang Fault, to the Santa Ynez Fault, to the San Gabriel Fault near San Bernadino (Tr. 9538-9539, 9639-9641) and thence to an unknown termination (Tr. 9669). Dr. Hall located the landfall of the Hosgri Fault on the basis of the abstract of the Fugro Report (PG&E Ex. 45; Tr. 9534). However, an examination of the full report indicated a contrary conclusion; the Hosgri terminates at a point offshore of Pt. Purisima. (Tr. 9681-9686).

In review of the number and complexity of the assumptions which Dr. Hall's theory requires, as well as the mass of previously cited testimony on the non-existence of any Hosgri connection with faults either to the north or the south, it is difficult for the Board to accord significant weight to the theory.

We now turn our attention to the third part of Contention 1.

> D. ... (iii) the nature, amount, and geologic history of displacements along the fault, including particularly the estimated amount of the maximum Quaternary displacement related to any one earthquake along the fault.

The main or central reach of the Hosgri Fault extends over a distance of about 60 miles, between the approximate latitudes of Point Sal on the south and Cambria on the north. Beyond this reach the fault extends about ten miles farther south and about 20 miles farther north to give a total length of about 90 miles. The evidence indicates that movement along the fault has involved right-oblique slip (i.e., slip having components of vertical and right-lateral strike-slip movement). The existence of an undisturbed sea-floor across the fault at most points near Estero Bay precludes any possible Holocene (up to 10,000 years ago) rupture along the north-central reach of the fault from exceeding a few thousand feet in length. (Applicant's Testimony at 115-120). The amount of possible lateral slip along the Hosgri Fault is limited. Both on its north end and on its south end, the Hosgri Fault is not through-going in the sense of connecting with other faults in a way that would permit transmission of tens of kilometers of lateral offset. The stratigraphic section penetrated by an oil well, known as the Oceano Well, located west of the fault is similar to the stratigraphic section of the adjacent region east of the fault. Further, the stratigraphy is unlike the section with which it should correlate if many tens of kilometers of right slip had occurred along the Hosgri Fault. The similarity of sections between the offshore well and the adjacent onshore region appears to limit possible lateral slip to a maximum of about 20 kilometers, although it actually could have been much less. The existence of a wider, more complex pattern of faulting in the Hosgri zone directly opposite the Point San Luis structural high on the Hosgri's northern section adjacent to the plant site, but not opposite Estero Bay further north along the strike, supports the argument that lateral slip in that region has not exceeded a few kilometers, at least over the last five million years. (Applicant's Testimony at 118, 119; Tr. 4930-4936, 4946, 4947, 4952-4954, 4957-4959).

Joint Intervenors presented Dr. Stephan A. Graham, who offered geological testimony concerning the amount of right lateral slip which occurred on the fault and the maximum size of the earthquake to be expected on such a feature. The testimony was received in evidence as J.I. Exhibit 48 (Graham).

Briefly, Dr. Graham theorizes that between five and fifteen million years ago the Hosgri-San Gregorio Fault system was a continuous feature as a key element of the plate boundary between the Pacific and North American plates, along which right lateral strike-slip movement of about 115 kilometers occurred (Tr. 6196-6198, 6364). This theory, based upon limited field work (Tr. 6233), depends upon the matching of seven pairs of geological features on the eastern and western sides of the fault. These features include the following: Fort Ross-Pilarcitos; Pt. Reyes-Ben Lomond Mt.; Pescadero-Ano Neuvo-Santa Lucia; Pigeon Pt.-Santa Lucia gravity data (Eli Silver datum); Big Sur-Miocene Sandstone; Big Sur-Cambria; and Pt. Sal-San Simeon (Clarence Hall datum). (Tr. 6172-6196). However, Mr. Hamilton challenged each of the seven sets of points developed or utilized by Dr. Graham, showing, as a result of extensive field work, that the alleged matching pairs of features do not match (Tr. 5166-5197). Furthermore, Mr. Hamilton presented convincing testimony limiting slip on the Hosgri Fault over the last 20 million years to a maximum of twenty kilometers, and probably more on the order of one-half that, and on the San Gregorio Fault to about ten kilometers (Tr. 4978, 4980). This consisted of stratigraphic and also geomorphic evidence. (Tr. 4981-5046). On cross-examination, it was made clear that Dr. Graham was expressing no opinion as to the current rate of slip of any of those faults, activity or movement on those faults in the past 17,000 years or five million years, and the capability of the Hosgri Fault today. (Tr. 6363, 6364).

Joint Intervenors presented as a rebuttal witness Dr. Clarence A. Hall, Jr., whose theory as to the amount of strike-slip movement on the Hosgri Fault was then discussed by PG&E witnesses. (Hall Testimony Tr. 9466-9696; Hamilton-Jahns Testimony at 109). Hall presented his theory that there has been about 80 kilometers of strike-slip motion along the Hosgri-San Simeon Fault system over the past nine million years or so. This theory is based largely on matching pairs of rocks found at San Simeon and at Point Sal (Tr. 9482) and on dissimilarities in rocks on opposite sides of the Hosgri Fault at those locations (Tr. 9511 A). As the Board noted in C, supra, he testified that the Hosgri and San Simeon Faults join at depth (Tr. 9530) and, in fact, he postulates a continuous fault beginning with the San Andreas north of San Francisco connected to the San Gregorio, San Simeon, down through the Hosgri and an extension of the Hosgri on land to the Lompoc-Solvang Fault to the Santa Ynez then to the San Gabriel and finally to the San Andreas again near San Bernadino (Tr. 9538-9539; 9639-9641) to an unknown termination (Tr. 9669). Hall supported his supposed landfall of the Hosgri Fault by reference to an abstract of the Fugro Report.

(PG&E Ex. 45; Tr. 9534). However, an examination of the full report indicated a contrary conclusion; i.e., that the Hosgri terminates at a point offshore of Pt. Purisima (Tr. 9681-9686).

In developing his theory of the amount of strike-slip movement on the Hosgri Fault, Dr. Hall contended that all significant strike-slip movement occurred after the formation of the Santa Maria pull-apart basin (Tr. 9619). In response to cross-examination, Hall stated that the relevance of the pull-apart theory to his theory as to the amount of strike-slip movement on the Hosgri is only historical in nature (Tr. 9693, 9694). He admitted he had no opinion as to the rate of movement on the Hosgri Fault over the last 17,000 years and no opinion regarding the earthquake capability of the Hosgri Fault (Tr. 9695, 9696). In any event, it appeared that the USGS had taken Hall's theory of movement into account in recommending a maximum 7.5 magnitude earthquake on the Hosgri Fault, and whether Hall is later proved to be correct or incorrect would not, therefore, alter the USGS judgment as to the earthquake potential of the region affecting the site (SER Supp. 4, Appendix C,. pp C-7, C-8; Tr. 9795). Earlier, Dr. Jahns and Messrs. Hamilton and Willingham convincingly reaffirmed the existence of the constraints they found to a large amount of movement on the San Gregorio Fault (Tr. 9958-9988; PG&E Exs. 46-50) and showed that the seven pairs of features relied upon by Dr. Graham to support his theory were, in fact, not uniquely correlative (Tr. 9989-10,003, 10,020-10,030; PG&E Exs. 51-58). Further evidence in conflict with Drs. Graham and Hall's theory was contained in the report prepared by USGS geologist Victor M. Seiders, which was introduced as Joint Intervenor's Ex. 110 (Tr. 9580). Mr. Seiders concludes that at most the evidence supports a maximum of about 35 kilometers of offset on the Hosgri Fault.

PG&E's concluding rebuttal witness on geology was Dr. Richard H. Jahns. He directed his testimony to Dr. Hall's theory and showed that his theory was physically and geologically impossible. Briefly, Dr. Hall testified that the pull apart basin in the general area of the curved breaks at the north end of the Transverse Ranges was created nearly thirteen million years ago, and that all the postulated movement on the Hosgri Fault occurred within the last five million years. However, there simply is no way to accommodate the 80 kilometers of movement on the Hosgri Fault, and thus Dr. Hall's theory fails (Tr. 10,031-10,079). Additionally, there exists today a pie-shaped piece of land between the Lompoc-Solvang fault and the Hosgri Fault (immediately above X' on PG&E's Ex. 43) that, according to Dr. Hall (Tr. 9668) came from an area east of Buellton during the past 5 million years. Dr. Jahns has stated that such a movement would necessitate that land moving across the Hosgri Fault, a geologic and physical impossibility (Tr. 10,037, 10,038).

The Staff's witness on this contention was Dr. J. Carl Stepp. He recited the Staff conclusions at the construction permit stages, and the extensive amount of new data developed by PG&E and others at the request of the Staff following discovery of the Hosgri Fault. Based upon a review of this data, he testified that the Staff concluded that PG&E had conducted an adequate investigation of the Hosgri fault which, when combined with data developed by others

> ". . . provides a basis for making a reasonable and conservative interpretation as to the length

> of the Hosgri Fault zone, its relationship to other regional tectonic structures, and the nature, amounts, and geologic history of displacements on the fault (Stepp Testimony following Tr. 8484 at 1-11).

He stated that the Staff also concluded that the Hosgri Fault does not appear to be directly linked to the San Simeon, and that the Hosgri has experienced strike-slip movement of at most only a few kilometers (Testimony at 11-23).

Accordingly, after considering all of the evidence, the Board concludes that PG&E has conducted an adequate investigation of the Hosgri Fault, that it is a feature about 145 kilometers in length ending in the north about thirty miles north of Estero Bay near Pt. Piedras Blancas, where it lies en echelon but not connected with the San Simeon Fault, in the south it dies out southward of Point Sal near Purisima Point within a zone of complex folding, and that the fault has experienced right lateral strike-slip motion of at most 20 kilometers over the last 20 million years.

B. The Hosgri Fault Earthquake Potential

CONTENTION 2

> A 7.5 magnitude earthquake is not an appropriate value for the safe shutdown earthquake.

The significance of Contention 2 is that the magnitude of the maximum credible earthquake which might occur on the Hosgri Fault bears a direct relationship to the vibratory ground motion one might expect at the site. Extensive evidence was introduced during the course of the hearing on this subject. However, as the Board has noted, supra, all parties appear to be in agreement that the assignment of a 7.5 magnitude is acceptably conservative for the safe shutdown earthquake. Regardless, the Board believes that a discussion of the evidence adduced at the hearing will help to place the assignment of this magnitude in the proper perspective.

The figure of 7.5 M was originally assigned as a potential magnitude for the Hosgri by USGS consultants to the Staff. (SER Supplement No. 4, Appendix C, May 1976). Although the USGS did not state specifically that a 7.5 M earthquake was likely to occur on the Hosgri in their report of April 1976, they set out reasons why they believed such an event could not be precluded. Those reasons were:

1. The Hosgri Fault zone is more than 90 miles long and may even be tectonically coupled to the San Simeon fault as they are within 2.5 miles of each other and both form parts of the eastern boundary of the Santa Maria Basin.

2. Marked changes in thickness and signature of acoustical units across the Hosgri Fault zone in several profiles indicates evidence of lateral slip. This was noted in the Survey's review of January 28, 1975, but such changes are even more abundant in the profiles of amendment 31 to the FSAR. Right lateral movement is reported for the San Simeon Fault. These data suggest that displacements on the Hosgri Fault are related to the highly active San Andreas plate-boundary system.

3. The length of the Lompoc Fault proposed by the Applicant as the most likely location of the 1927 event appears incompatible with the magnitude of the 1927 earthquake.

4. The Hosgri Fault is closer to the center of the estimates of error of both Engdahl and Gawthrop than any other fault. It is therefore a possible source of the 1927 earthquake.

5. Questionable evidence relating to vertical displacement on the Hosgri Fault in the epicentral area of the 1927 earthquake does not eliminate it as a source. Surface rupture is generally discontinuous, and if

> lateral slip occurred, if probably would not be detected. Offset of the base of post-Wisconsinan sediments and probable faulting of them is evidence of Post Pleistocene movement.

PG&E's witnesses on seismology were Drs. Bruce A. Bolt, Gerald Frazier, and Steward W. Smith. Drs. Bolt and Frazier adopted the testimony prepared by Dr. Smith (Tr. 5447, 5448). He testified that the seismic analysis done at the construction permit phase of the proceeding provided a number of conservatisms which could be relaxed in light of present day knowledge and data, and that use of a magnitude 7.5 earthquake on the Hosgri Fault in the reanalysis of the plant is grossly conservative (Testimony following Tr. 5490 at 1-6; Tr. 5692).

Dr. Smith testified that in order to assess the earthquake potential of a fault one should take into account amount of slip, type of faulting and proximity of plate boundaries. Efforts to establish continuity in order to determine the total length of a fault system are not very useful if the primary intent is to establish the potential for future earthquakes (Tr. 5676, 5688, 5689). However, the amount of fault slip that has taken place over recent geologic time appears to be a significant measure of the amount of earthquake activity that has occurred (Tr. 5691). If, for example, a fault has had kilometers of slip it must have had a substantial length during the time that slip accumulated. This would be true irrespective of whether the geologic data is adequate to show continuity of a single fault trace. (Testimony at 6-8).

Dr. Smith stated that it is also important to consider the time frame within which the fault slip has taken place. The existence of a fault slip many millions of years ago may have little or no relevance to the present day seismic potential of that fault. The last 20,000 and particularly the last 17,000 years is an appropriately conservative interval on which to base an assessment of fault activity. (Testimony at 8-9; Tr. 5549, 5824-5829).

Dr. Smith testified that one should ask what the tectonic framework can reveal about stress conditions on the fault in question. This is important because stress conditions are more likely to control a ground motion parameter, such as peak acceleration, than is earthquake magnitude. Regions undergoing normal faulting, a situation characterized by horizontal tension, typically produce lower-stress earthquakes than those associated with thrust faulting, in which horizontal compression is dominant. Strike-slip faulting is likely to be intermediate between these two extremes. In addition to the local style of faulting, the proximity of the region to major plate boundaries is important in assessing what the stress conditions are likely to be. Thus, faults closest to the main break of the San Andreas appear to have the largest amount of late Quaternary (up to two and one-half million years ago) displacement, while those such as the Hosgri have progressively less displacement the further removed they are from the San Andreas Fault, the present plate boundary (Testimony at 9-11; Tr. 5829, 5830, 5833, 5834, 5839).

Applying these principles to the Hosgri Fault provides the following:

a) Slip history of the Hosgri Fault during the late Quaternary period is only several meters, indicating that during this time it was not operating as part of a long fault system.

b) Focal mechanisms and geologic data show that deformation changes from right lateral shear on the San Andreas to normal faulting in the offshore Santa Maria Basin. The local stress conditions for the Hosgri would thus be expected to be intermediate between normal faulting and strike-slip faulting--that is, significantly less than those expected for compressional regimes.

c) The Hosgri, some 80 kilometers from the San Andreas, is much less affected by the stress field from this plate boundary than those faults which are closer to or intersect the San Andreas, and thus the stress levels and earthquake potential are correspondingly less on the Hosgri (Testimony at 11).

The Southern Coast Range Province in which Diablo Canyon is located is an area of low-to-moderate seismicity. Major activity is centered on the San Andreas fault about 80 kilometers to the east, and in the Transverse Range Province about the same distance to the south. As explained by Dr. Smith, his approach has been to assume that all the recognized faults in the Southern Coast Range Province are seismically capable, and that their potential activity in the future can be best estimated by examining their geologic record of slip in the past. Available evidence points toward a gradual transition from the right-lateral shear environment near the San Andreas Fault to a tensional environment in the offshore on the Santa Lucia Bank Fault. If the offshore region is one of transition to a tensional rather than a compressional regime, this would significantly reduce the potential for high-stress, high-peak-acceleration earthquakes on the Hosgri or other nearby faults. (Testimony at 14-16).

As stated earlier, Dr. Smith examined both the seismic and geologic history of the region and concluded that to assure a very conservative estimate of future seismic potential the emphasis should be placed on the geologic record, particularly over the last approximately 17,000 years. (Tr. 5549). However, recent developments in the use of seismic moment[6/] make it possible to directly assess the present day seismicity in terms of slip rates and thus test the idea of whether or not the current rate of earthquake activity is consistent with the geologic record of fault slip (Testimony at 16, 17; Tr. 5531, 5547).

The first approach to relating seismic history to fault slip through seismic moment was done by examining the average seismicity during the last half century in the Southern Coast Range Province, excluding both the San Andreas

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6/ During the past decade seismic moment has come into common use in seismology as an effective means to characterize the size of an earthquake. The type of dislocation caused by an earthquake in an elastic medium can be represented mathematically in terms of its equivalent force system--that is the pair of forces that would have to be applied to produce the same elastic displacements throughout the medium. The moment of these forces turns out to be simply the product of the average slip, the fault area, and the rigidity of the surrounding rocks. Seismic moment can also be related empirically to earthquake magnitude, thus making the link to relate geologically observable quantities to seismological data (Testimony at 17; Tr. 5532, 5781, 5782).

and the Transverse Ranges. The result shows the usual type of size distribution for California earthquakes. Distributing these earthquakes over the four principal northwest trending fault zones (Hosgri, Rinconada, Nacimiento, and Santa Lucia Bank) permits one to calculate a return period for earthquakes of a specified magnitude on each fault zone. Thereafter, the postulated seismic activity can be converted into an estimate of fault slip by means of the seismic moment. Each of the four faults would have to be assumed to span the entire region sampled, thus making them about 200 kilometers long. A rough calculation shows that one magnitude 6.5 earthquake every 700 years along a 200 kilometer fault will lead to a net slip of about 1.5 meters over the past 17,000 years. (Tr. 5700). Since observations of surface faulting show the slip locally may exceed two or three times the average slip, one would expect to see, locally at least, a slip of several meters from this postulated level of seismic activity. This is in fact what has been observed in the seismic profiles across the Hosgri, leading to the conclusion that this level of seismicity, up to magnitude about 6.5, is likely to represent the maximum that has occurred here. (Tr. 5801). Similar calculations assuming a magnitude 7 lead to a total average slip during the past 17,000 years of about three meters. From this one could expect to see slip locally exceeding two or three times this amount. Fault slip on the Hosgri, if there were to be any, would have roughly comparable components of vertical and horizontal motion. (Tr. 5550, 5551, 5553-5555, 5559). It is unlikely that large amounts of horizontal slip could have occurred on the Hosgri without their having been recognized in the data available. (Tr. 5574, 5575, 5586, 5587). Since fault slip of this magnitude would have produced a more significant and pervasive record of sea-floor disturbance along the Hosgri, even if it were primarily horizontal in direction, it can be concluded that earthquakes of this size cannot have been characteristic of this region during the last 17,000 years. (Testimony at 18-20; Tr. 5520, 5521, 5533-5546, 5548, 5549, 5560). In other words, there have not been recurrent earthquakes abcve 6.5 magnitude on the Hosgri in the past 17,000 years. (Testimony at 29).

In an effort to further test these ideas and examine the sensitivity of the result to the size of the region over which seismicity was sampled, the analysis was extended to include the entire plate boundary region from Cape Mendocino to Baja California. After apportioning the seismic activity in the region between the San Andreas and the various secondary faults which parallel it, about 5% of the San Andreas activity is found on the Hosgri. This leads to an average return period for a magnitude 6.5 earthquake on the section of the Hosgri adjacent to Diablo Canyon of about 1,000 years, which is consistent with the earlier result. (Testimony at 20-21; Tr. 5570, 5810, 5811).

To further check the consistency of this approach it can be applied directly to the San Andreas, where a good deal more is known about the history of slip. One commentator (Sieh) has estimated recurrence rates of great earthquakes on the San Andreas from which slip rates may be inferred of from 3.7 to 6.0 centimeters per year. Using the last half century of instrumental data on earthquake occurrences, predicted earthquakes produce a slip rate of only two centimeters per year. Thus, the sample of seismicity during the last 45 years appears to underestimate the plate boundary motion by a factor of about 2 or 3. This type of agreement is considered satisfactory, considering that a significant part of the plate motion may take place as creep, or that the period of time sampled was not as seismically active as the average. In either case, the inference drawn regarding the Hosgri would be expected to err on the side of conservatism. (Testimony at 20-22; Tr. 5756, 5769, 5770).

Dr. Smith also presented the evidence on which he bases his belief that the Lompoc or Pt. Arguello 1927 earthquake did not occur on the Hosgri Fault. Preliminarily, Dr. Smith listed the most severe effects resulting from this earthquake and noted that even if the earthquake had been on the Hosgri adjacent to the site it would pose no ground motion problem more severe than those considered in the original design of the plant. Briefly, the evidence Dr. Smith brings to bear concerning the location of the 1927 earthquake is as follows:

a) The type of data used to locate the event in the study upon which USGS relied in arriving at its conclusion that the event may have occurred on the Hosgri (arrival times of seismic waves at distant recording stations) was unreliable.

b) Interval times between shear and compressional waves for aftershocks provide more reliable data.

c) The available intensity data shows that the pattern of lines of roughly equivalent earthquake damage would put the earthquake directly offshore from Point Arguello.

d) Consideration of the sea-floor topography shows that there are no sea-floor offsets along the Hosgri that appear as if they could have been associated with this earthquake.

When taken together, Smith believes that this evidence points convincingly toward the Lompoc structure as the source of the 1927 earthquake. (Testimony at 22-25; Tr. 5483, 5484, 5635-5645). Dr. Jahns and Mr. Hamilton also believe that the 1927 earthquake occurred in the Lompoc rather than the Hosgri Fault. (Tr. 5319, 5483, 5484). The Fugro Report, done for the USGS in late 1978 (PG&E Ex. 45), concludes that the evidence does not favor speculations that the 1927 Point Arguello earthquake occurred on the Hosgri Fault.

Joint Intervenors' witness Silver testified that in his opinion the Hosgri-San Gregorio Fault System was a continuous fault zone extending at least 400 kilometers from near Bolinas to south of Point Sal. Using a formula developed by Dr. Smith and filed as part of the FSAR, Silver computed a possible maximum earthquake on the Hosgri Fault of magnitude 8.25, a much higher number than that produced by Dr. Smith. This arose from the use of higher input numbers in the formula, namely the 400 kilometer fault length, a rate of slip of 1.6 centimeters per year and a time span of only 1000 years. The witness emphasized that the result was a maximum, an "outer expected magnitude". (Tr. 6203-6224, 6434, 6435, J.I. Ex. 49). Using a different method and again assuming the fault broke over its entire length of 400 kilometers, he calculated a maximum earthquake of magnitude 8. (J.I. Ex. 49; Tr. 6203-6224). On cross-examination, Dr. Silver acknowledged that a recent gravity map introduced some uncertainties in his theory of large offset along the San Gregorio Fault at a point suggested by Silver and constituting one of the seven matching points relied upon by Graham. (Tr. 6250-6259). In addition, substantial errors in plotting offshore data collected by Silver were uncovered. (Tr. 6264-6297). Further, Dr. Silver admitted that he was not aware of any earthquake fault zone that had ever ruptured over its entire length during a single event, and that "generally" this does not occur. (Tr: 6354, 6442, 6453). A later USGS witness agreed. (Tr. 8335). Mr. Hamilton previously testified that it would be conservative to assume that one-half of the total length of a fault will experience rupture during an earthquake. (Tr. 4877). With regard to using Dr. Smith's formula, Dr. Silver conceded that several of the numbers he (Silver) used were arbitrary, that the amount of slip he used was based on interpretive measurements taken at one location on the San Gregorio Fault and was not necessarily applicable to the Hosgri Fault, although he applied the rate to his full assumed length of the fault, that a later study of the same area on the San Gregorio Fault showed no slip at all over a 16-year period, and that he did not know whether in his formula Dr. Smith used fault zones or faults. Finally, Dr. Silver was unable to state within a reasonable degree of geologic certainty that an earthquake as large as a 6.5 magnitude had or would ever occur on the Hosgri Fault. (Tr. 6333, 6344, 6437-6442, 6447-6453). Earlier, Dr. Smith testified why he found his formula too conservative and thus avoided using it for his testimony. (Tr. 5776, 5777, 5781-5783).

Dr. Mihailo Trifunac, called by Joint Intervenors as a witness, did not believe a 7.5 magnitude earthquake would be appropriate for the Hosgri. He believed a 6.5 magnitude would be more appropriate. (Tr. 8971).

At the conclusion of his testimony, the Board asked Dr. Smith and the other panel members how the Board could be confident that another Hosgri-type fault was not lurking offshore. (Tr. 6030). Dr. Smith replied that there certainly are other offshore faults in the area but that none could be of such significance as to affect the conclusions concerning the safety of the Diablo plant. This follows from the fact that the original design parameters established in 1967 were so conservative that the Hosgri or any similar type structure would not be large enough to take the Diablo plant beyond the envelope of the limits proposed in those days. It was also pointed out that the rocks in California are of a type that can only store up so much energy and thus there is an upper limit on the amount of earthquake energy which can be released. Also, the tremendous amount of offshore data which has been gathered has given a vastly improved general understanding of the structures and location of offshore faults, at least as far as the distance onshore to the San Andreas. In other words, there is no unexplored region in the offshore area of interest, and the information available precludes the existence of any fault that could be as large as the Hosgri or as influential in the plant design. (Tr. 6026, 6030-6033).

Two representatives from the USGS, Messrs. James Devine and Francis McKeown, appeared on behalf of the Staff. They testified in support of the report they wrote which was filed as Appendix C of Supplement 4 to the SER. Among other things the report concludes that an earthquake similar to the 1927 Lompoc earthquake could occur anywhere along the Hosgri Fault, that the Hosgri, San Simeon, and San Gregorio Faults are subsidiary faults within the San Andreas system, that such faults have not been demonstrated to be capable of magnitude 8+ earthquakes, and USGS Circular 672 should be used to form the basis of a description of an earthquake postulated to have the potential for occurring on the Hosgri Fault. (Appendix C; SER Supp. 4, pp. C-15, C-16). Although the letter transmitting the report is dated April 29, 1976, the witnesses testified that the report reflected their present opinion, and if they were issuing the report today the content would be essentially the same. (Tr. 8194). They also testified that there was no disagreement between various members of the USGS as to the conclusions in the report. (Tr. beginning at 8218). In response to Board questions, they testified that they would not expect an earthquake on one of the faults of the Hosgri-San Simeon-San Gregorio Fault system to cause an earthquake to occur on one of the other faults in the system. (Tr. 8334-8335), and they expressed agreement with the earlier testimony of Mr. Hamilton and others, and the Board agrees, that it is inconceivable that a fault more significant to the plant site than the Hosgri lies offshore waiting to be discovered. (Tr. 8337, 8338).

Dr. Stepp, one of the Staff witnessses on this contention, testified that the 1927 earthquake could have occurred on the Hosgri but that, on balance, it probably was associated with the Transverse Ranges structures and that, in any event, it was very conservative to assume a 7.5 magnitude earthquake on the Hosgri Fault (Testimony at 12, 31, 32). The other Staff witness on this contention, Renner B. Hofmann, concluded that the 1927 Lompoc earthquake did not occur on the Hosgri Fault. (Tr. 8533-8535), and that the assignment of a 7.5 magnitude earthquake to the Hosgri Fault was extremely or ultra-conservative (Hofmann Testimony on Contention 2 following Tr. 8522 at 1-5; Tr. 8539).

Accordingly, the Board concludes that a 7.5 magnitude earthquake is a very conservative value for the safe shutdown earthquake. We also find that the requirement imposed by the Staff that a 7.5 magnitude earthquake be used by the Applicant in its seismic analysis is reasonable and meets regulatory requirements.

C. <u>Peak Instrumental and Effective Acceleration</u>

<u>CONTENTION 3</u>

> A 0.75g acceleration assigned to the safe shutdown earthquake is not an appropriate value for the maximum vibratory acceleration that could occur at the site.

The central controversy with respect to this contention is whether the acceleration value for anchoring or scaling response spectra should be 0.75g or 1.15g. The 0.75g value is the anchor point used by Applicant (Blume Testimony following Tr. 6100). and by Staff (Newmark Testimony following Tr. 8552) for scaling response spectra which represented the expected ground motion at the Diablo Canyon site from a hypothetical 7.5 magnitude earthquake on the Hosgri Fault. The 1.15g value is the peak acceleration given in Table 2, for magnitude 7.5, of U.S. Geological Survey Circular 672 (Intervenor's Ex. 45). Intervenor's witness, Dr. J. E. Luco, took the position that reduction from a peak instrument acceleration of 1.15g to an effective acceleration of 0.75g was not warranted (Tr. 8877-80, 8971-72, 9137). Intervenor's witness Dr. M. D. Trifunac, stated that he was satisfied with the use of 0.75g as proposed by Dr. Newmark because he believes that a postulated earthquake of 6.5M would be reasonable for the Hosgri analysis.

(Tr. 8971, 8985, 9230). Intervenor's witness Dr. Brune testified that due to uncertainties inherent in extrapolation from a small data base, and the possibility of such seismic phenomena as focusing, actual peak acceleration could be twice as high as indicated in USGS Circular 672.(Tr. 7963, 8056-8058). The basic question then is whether or not the effective acceleration of 0.75g used by Applicant and Staff for developing ground response spectra is appropriate to represent the safe shutdown earthquake.

Dr. John A. Blume (following Tr. 6100) provided written testimony concerning basic seismic terminology, the procedures involved in calculating response spectra, and the criteria used to evaluate the Diablo Canyon plant for the postulated 7.5 magnitude earthquake. The basic inputs for calculating a response spectrum are a complete time history of the ground motion produced by a seismic disturbance and a series of simple, elastic, oscillators having the same damping but different natural periods of vibration. Each oscillator is subjected to the time history of motion and its maximum response is calculated. The resulting graph of maximum acceleration (in gravity units) versus vibratory period (in seconds) is the acceleration response spectrum for the particular time history and the particular series of damped oscillators considered in the analysis. The peak instrument acceleration is the highest acceleration indicated by the time history of motion while the effective acceleration is the same as the spectral response at zero period or infinite frequency. At frequencies above 20 hertz effective acceleration is essentially constant and is also referred to as zero period acceleration or anchorpoint acceleration. This distinction between peak instrument acceleration and effective acceleration was not challenged by any of the parties.

At page 2 (following Tr. 6100) Dr. Blume states that:

> "The effective acceleration used as the basis for the evaluation of the Diablo Canyon plant for the hypothetical 7.5M earthquake on the Hosgri Fault is 0.75g. However, the peak instrumental acceleration from which that value was derived is 1.15g".

Dr. Blume pointed out that the postulated 7.5M earthquake on the Hosgri Fault was in accord with the USGS recommendation, which he considered to be quite conservative for a variety of reasons detailed in his testimony.

It was staff witness and consultant, Dr. Nathan M. Newmark (written testimony following Tr. 8552) who proposed that the peak instrumental acceleration of 1.15g cited in USGS Circular 672 for a 7.5M earthquake be assigned an effective acceleration of 0.75g for the purpose of developing ground response spectra. Dr. Newmark's basis for this proposal is described in Reference "A" of his written testimony. In brief, he uses the time history records of the Pacoima Dam earthquake of February 9, 1971, which show a peak instrumental acceleration of 1.2g, to calculate a ground response spectrum. Then, using an anchorpoint or effective acceleration of 0.75g and following procedures very much the same as described in NRC Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants", he constructed design spectra for various damping values (Figure 1a of Reference A following Tr. 8552). The design spectrum for 2 percent damping generally encloses, by a substantial margin on the whole, the Pacoima Dam response spectrum. Dr. Newmark concludes (at p. 3 of Reference A) that:

> "This is the most direct indication that the 'effective' peak acceleration for the Pacoima Dam record is not in fact the measured value of 1.2g, but actually does not exceed 0.75g. Therefore this is taken as the effective peak acceleration for design."

Dr. Luco, an ACRS consultant subpoenaed by Intervenor, took the position that if one uses a design basis earthquake of 7.5M as recommended by USGS, one should also use 1.15g, i.e., the corresponding instrumental acceleration value in Table 2 of USGS Circular 672, as the anchorpoint or effective acceleration for development of ground response spectra. This position is contradicted by the testimony of Drs. Blume and Newmark, supra, and by the USGS report of April 1976 (SER Supp. 4, Appendix C) which has the following to say with respect to the values in USGS Circular 672:

> "7. We repeat our opinion that, for sites within 10 km of the surface expression of a fault, the description of maximum earthquake ground motion by means of a single acceleration value may not be an appropriate representation.
>
> Consequently, we feel that an appropriate earthquake for this site should be described in terms of near-fault horizontal ground motion. A technique for such a description is presented in the Geological Survey Circular 672 entitled 'Ground Motion Values for Use in the Seismic Design of the Trans-Alaska Pipeline System' (Ref. 4). It is our intention that the ground motion values as exemplified by Table 2 'Near-fault horizontal ground motion' of Ref. (4) for magnitude 7.5 be used to form the basis of a description of the earthquake postulated to have the potential for occurring on the Hosgri Fault at a point nearest to the Diablo Canyon site subject to the conditions

> placed on these values in Ref. 4. The earthquake so described should be used in the derivation of an effective engineering acceleration for input into the process leading to the seismic design analysis." (Emphasis added)

Dr. Luco further based his opinion concerning the selection of 1.15g to characterize the peak acceleration associated with the postulated 7.5M earthquake on the Hosgri Fault within 10 km of the Diablo Canyon site on calculations made by himself using correlations developed by Dr. Trifunac. Dr. Trifunac, on the other hand, testified that he would have preferred to postulate a 6.5M earthquake on the Hosgri Fault (Tr. 8971); and that given such a postulate, he would expect a peak acceleration in the vicinity of 0.7 to 0.8g.

Dr. Blume made it clear that he believes that the 7.5M and 0.75g effective acceleration values postulated for the safe shutdown earthquake for the Diablo Canyon plant are too conservative, and that a 6.5M and 0.5g effective acceleration would have been adequate for the seismic re-evaluation (pp. 15-18 following Tr. 6100). The general opinion that the postulated earthquake parameters, a 7.5M earthquake on the Hosgri Fault and an effective acceleration of 0.75g at the Diablo Canyon site, are indeed conservative was supported by Dr. Seed (Tr. 10,102-10,108), Dr. Frazier (Tr. 10,113-10,117), Dr. Bolt (Tr. 5876-5880), Dr. Stepp (p. 12 following Tr. 8484) and Mr. Hofmann (Tr. 8539, 8540).

Dr. Seed's testimony (Tr. 10,192 et seq.) was based on the limited data presently available for peak accelerations measured at distances less than 10 km from earthquake epicenters. A plot of peak near field acceleration versus earthquake magnitude shows that for earthquakes of 6.25M and above the peak near field acceleration is essentially constant (Applicant's Exhibits 61, 62, and 63) and has a mean value (Tr. 10,016) of about 0.6g. From this analysis and other considerations, Dr. Seed concludes (Tr. 10,108) that there is no need to introduce the concept of effective acceleration in this case, and that:

> "The actual mean acceleration associated with the magnitude 7.5 earthquake on the Hosgri fault is less than 0.75g, and this is the value used to anchor the spectrum in accordance with customary NRC procedures."

The clear implication of Dr. Seed's testimony is that using 0.75g is a conservative anchorpoint for the design response spectrum even when the distinction between peak instrumental and effective acceleration is disregarded.

Dr. Blume also discussed the probabilistic aspects of peak ground acceleration. Based upon a number of studies and analyses, Dr. Blume concluded that if a 7.5 magnitude earthquake is considered possible on the Hosgri Fault, a 1.15g instrumental acceleration would have an average return period of about 100,000 years. The effective acceleration--.75g--associated with the 1.15g instrumental acceleration has the same average return period--roughly 100,000 years (pp. 33-37 following Tr. 6100).

Intervenor's primary witness on this point was Dr. James N. Brune. Basically, his testimony was that, because the data base is so small, uncertainties exist, and accelerations and velocities could be a factor of two greater than those postulated in USGS Circular 672 (Tr. 7963). These greater accelerations could arise from such phenomena as focusing (directivity) (Tr. 7936, 7937) or high stress drops (J.I. Ex. 66, pp. 3-2, 3-3; Tr. 7938, 7939). Focusing it is not a new phenomenon (Tr. 7953, 7956, 7957). Dr. Brune cautioned that these higher numbers are based on extrapolations of very limited data and thus of low confidence (J.I. Ex. 66, pp. 3-9), and he presented specific arguments which might be cited against the possibility of these higher numbers (J.I. Ex. 66, pp. 3-16 - 3-18). He concluded, however, that because of the limited data base the higher values were at least theoretically possible (Tr. 8056-8058). The witness could not assign a level of probability to his higher values (Tr. 8143) except to describe them as being "low" for any given earthquake (Tr. 8144). There was also testimony that only two such higher values had ever been recorded--one from the Russian Gazli earthquake, for which a vertical acceleration of 1.3g was recorded (Testimony at 3-4), and one from the Pacoima Dam record (1.2g), (Tr. 5846, 7977). It was also developed that in every case there was more than one possible explanation for the points raised in his testimony (Tr. 8059-8080). Considering all of the evidence, the Board is of the opinion that the speculated higher values postulated by Dr. Brune are not of design or analytical significance for the Diablo Canyon Plant.

Based on the record, as reviewed, supra, the Board concludes that the 0.75g acceleration assigned to the safe shutdown earthquake is an appropriately conservative value for the maximum vibratory ground acceleration that could occur at the Diablo Canyon site and thus an appropriate anchorpoint (or maximum ground acceleration as defined by NRC Regulatory Guide 1.60) for design response spectra.

D. Operating Basis Earthquake

CONTENTION 4

> The maximum vibratory acceleration of .2g for the operating basis earthquake is not one-half of the maximum vibratory acceleration of the safe shutdown earthquake.

Appendix A, Section V, paragraph (a)(2) of 10 CFR 100 specifies that the maximum vibratory ground acceleration of the Operating Basis Earthquake (OBE) shall be at least one-half the maximum vibratory ground acceleration of the Safe Shutdown Earthquake (SSE). Appendix A also says, in relevant part, that the OBE is "... that earthquake which ... would reasonably be expected to affect the plant site during the operating life of this plant ..." (Section III, paragraph (d)), and Section II states that departures from this criteria specified in Appendix A are permitted with proper justification.

Diablo Canyon was originally designed to a "Double Design Earthquake" (now the SSE) with a maximum vibratory acceleration of 0.4g and a concomitant "Design Earthquake" (now the OBE) with a 0.2g acceleration. Following the discovery and subsequent investigation of the Hosgri Fault, the Applicant was required to modify the plant, where necessary, to withstand an SSE with a maximum vibratory acceleration of 0.75g. The OBE, however, was maintained at an acceleration of 0.2g rather than the 0.375g which the bare words of Section V, paragraph (a)(2) of Appendix A would lead us to. The Applicant maintains, and the Staff agrees, that setting the OBE acceleration at 0.2g satisfies the overall requirements of Appendix A. (Hoch Testimony, pp. 18-21, following Tr. 6879; Tr. 8423-8426, 8471, 8472).

The Board has reviewed Appendix A and the Statement of Considerations which accompanied the September 1, 1978 revision. In the discussion in the Statement of Considerations of changes to Section V, "Seismic and Geologic Design Bases" we find the following:

> Paragraph (a)(2) of Section V has been changed to require the Applicant to specify the Operating Basis Earthquake. A requirement which reflects the seismic design bases for plants recently evaluated for construction permits that the maximum vibratory ground acceleration of the Operating Basis Earthquake shall be at least one-half the maximum vibratory ground acceleration of the Safe Shutdown Earthquake has been added.

The language of this clarifying statement together with the total text of Appendix A leads the Board to believe that the OBE requirement was intended to apply to the original design basis at the construction permit stage, and is not necessarily applicable to the instant case. Further, the arbitrary nature of the quantitative requirement, based as it is upon "... the seismic design bases for plants recently evaluated ..." appeals to us as more of a guideline for prudent design rather than an iron-clad necessity for Regulatory approval. The Board, of course, has no intention of ignoring the requirement, but does believe that these considerations offer a firm foundation for relief, in the instant case, under the provisions of Section II, "Scope" of the Appendix.

The NRC has accepted an OBE for other plants of less than one-half the SSE (Tr. 7843-7845) on the basis of a probabilistic analysis estimating the exceedance probability and return period for such an earthquake. (Hoch Testimony following Tr. 6879 at 9-12). The principle is that an OBE is one which would reasonably be expected to affect the plant site during the operating life of the plant. The Staff has stated that it considers that an earthquake that exhibits an exceedance probability of no more than 30% and a return period of no less than approximately 110 years could reasonably be expected to affect a plant site and produces a conservative acceleration level for the OBE. PG&E conducted its own analyses, taking into account the various factors specified in Appendix A to 10 CFR 100, which produced a range of exceedance probabilities and average return periods. For a peak instrumental acceleration at the site of 0.20g, the lowest average return period computed by any of the methods used in the analysis is 275 years, and the corresponding exceedance probability for a 40-year plant lifetime is approximately 14.5%. Since the return period is more than twice the 110 year period specified by the Staff and the exceedance probability is less than one-half that specified by the Staff, an OBE of 0.2g is acceptable and it has, in fact, been accepted by the Staff. (Testimony following Tr. 6879 at 9-12; SER Supp. 7, pp. 2-4, 2-5; Tr. 6909, 6910).

The NRC project manager for the Diablo Canyon Plant affirmed that the proposed OBE conforms to the requirements of Appendix A to 10 CFR 100. (Tr. 8423-8426, 8471, 8472). Staff witness Dr. Newmark stated that in his opinion, and that of many engineers, the proper value for an OBE is from one-fourth to one-third of the SSE. (Newmark Testimony at 6). Moreover, in testing plant electrical equipment for the Hosgri event, an OBE equal to or greater than 50% of the SSE was used. (Tr. 7845, 7846). It should also be noted that the safety of plant systems and components is measured against codes which exceed the lower OBE value. Hence, the safety of the plant is not controlled by the OBE, but by the various codes. (Tr. 8707-8709).

Testimony on the OBE was offered on behalf of Joint Intervenors by Richard B. Hubbard. (J.I. Ex. 65). After extensive examination on voir dire the bulk of his testimony was stricken as being beyond the technical expertise of the witness. (Tr. 7708-7800, 7832-7838, 7861-7869). No evidence was presented demonstrating that the use of 0.2g for the OBE would result in any undue risk to the public health and safety. In fact, the Board concludes that setting the OBE at 0.2g, rather than a higher level, will require PG&E to shut the plant down for inspection at a lower acceleration than otherwise, thereby adding a further safety feature.

Accordingly, the Board finds that use of an operating basis earthquake of 0.2g is reasonable for the Diablo Canyon facility.

E. Response Spectra and Seismic Design

CONTENTION 5

> The Applicant has failed to demonstrate, through the use of either appropriate dynamic analysis or qualification tests (or equivalent static load method where appropriate), that Category I structures, systems, and components will perform as required during the seismic load of the safe shutdown earthquake, including aftershocks and applicable concurrent functional and accident-induced loads, and that Category I structures, systems and components will be adequate to assure:
>
> A. The integrity of the reactor coolant pressure boundary;
>
> B. The capability to shut down the reactor and maintain it in a safe condition; or
>
> C. The capability to prevent or mitigate the consequences of accidents which could result in excessive offsite exposure.

CONTENTION 6

> The Applicant has failed to demonstrate, through the use of either appropriate dynamic analyses or qualification tests (or equivalent static load methods where appropriate), that all structures, systems and components of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public will remain functional and within applicable stress and deformation limits when subjected to the effects of the vibratory motion of the operating basis earthquake in combination with normal operating loads.

CONTENTION 7

> The Applicant has failed to demonstrate adequately that necessary safety functions are maintained during the safe shutdown earthquake where, in safety-related structures, systems and components, the design for strain limits is in excess of the yield strain.

Using .75g acceleration as the value against which to design for the safe shutdown earthquake (SSE), the Applicant and Staff testified that adequate testing and analysis has been performed to demonstrate that Category I structures, systems and components would perform as required during the seismic load of the SSE and will remain functional and within the applicable stress and deformation limits.[7/]

Given an acceleration of .75g, response spectra can be developed for analysis of the structures, components and equipment. PG&E through Dr. Blume, and the Staff, through Dr. Newmark, devised such spectra. The use and understanding of the term response spectrum (plural "spectra") was given by Dr. Blume in his testimony as follows: (Blume Testimony at 5-8, Tr. 6100).

The response spectrum is an extremely important concept in the analysis and design of nuclear power plants for earthquake motion. If a complete time history of motion is used as the disturbance input, it is possible to calculate the maximum response of a simple one-degree-of-freedom elastic, damped oscillator when subjected to the entire time history of motion. Such a simple oscillator might be represented by a single rigid mass on a vertical stick having stiffness

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7/ Knight Testimony at 19-54. Testing and analysis is discussed in excrutiating detail and was not challenged by Intervenor.

but no weight, or a "lollipop" shape. The results of such a calculation would produce only one point for a response spectrum curve and that point would be for the natural period of vibration of this particular oscillator with its particular damping ratio. If a whole series of oscillators of the same damping are subjected one at a time to the same ground motion record, and if each oscillator has a different natural period, there would be a whole series of points for a plot of maximum acceleration versus period. Connecting these points would provide a "response spectrum" for the particular ground motion record and for the particular damping of the oscillator. If the same procedure were repeated using oscillators with other damping values, a whole family of spectral curves would be obtained for the particular strong motion record. Of course these extensive calculations are done in computers.

Most acceleration response spectra made from an earthquake record are rather ragged with many peaks and valleys. It is customary to obtain smooth curves for use in analysis and design in order to avoid the problems associated with these peaks and valleys and to avoid sensitivity in response caused by minor variations in natural period. There are various ways this "smoothing" can be done. One simple way is to draw the smooth curve through the jagged one either by averaging the peaks and valleys or, as is more often done, to almost envelope the peaks. A better way is to not rely upon one ground motion time history but to use several appropriate records representing as near as possible the conditions under consideration. This results in a whole series of response spectra for each damping value which series can then be treated statistically by various methods to obtain an average curve for all the records used as well as other curves representing any statistical deviation from the average that may be desired. This procedure has the advantage of not only providing a broader base of information but of providing probabilistic distributions at any period value or statistical confidence level of interest.

Response spectra can also be constructed artificially, or they can be obtained from standards like NRC Regulatory Guide 1.60, or from ratios of spectral values to either ground acceleration, velocity or displacement, depending upon the period or frequency under consideration. It so happens that effective acceleration used to construct spectral curves is the same as spectral response at any damping value at zero period or infinite frequency. Effective acceleration is therefore sometimes referred to as zero period acceleration or anchorpoint acceleration.

It is often convenient in analysis to use a time history instead of a response spectrum. However, as discussed previously, time histories produce spectra with peaks and valleys. To overcome this problem a time history is selected to best represent the conditions of the problem and it is then artifically altered, usually with additions of pulses of proper sizes and at strategic locations in the time domain to cause the spectrum made from the modified time history to closely match the prescribed spectral diagram. This work has to be carefully done and, of course, with computer aid.

Dr. Blume reviewed how he developed his basic response spectra, based upon the 0.75g anchor value and using the damping values conforming to NRC Regulatory guide 1.61. (Blume Testimony at 39-47). Development of response spectra was also undertaken independently by Dr. Newmark, (Newmark Testimony, Reference "A" at 2) and both spectra were used in the analysis with the more conservative in any particular instance governing. Thus, two complete analyses had to be made. (Blume Testimony at 38-41). Dr. Blume compared the two peak ground acceleration values (his and Dr. Newmark's) showing that they were consistent. (Blume Testimony at 42-43).

In addition to being critical of anchoring the initial response spectrum to .75g, Drs. Luco and Trifunac were critical of further reducing, in some instances, response spectra due to factors such as tau and 7% rather than 5% damping. (Tr. 8895, 8972, 9823-926, 8971-972). However, no testimony critical of the procedures of developing the basic response spectrum by either Drs. Blume or Newmark was given. As respects tau and damping, there was a great deal of testimony.

"Tau" was defined as a simplification of a very complex wave motion-structure action problem. The tau effect is ascribed to the fact that all points on the foundation of a building do not respond in phase. As a result, the motion of the foundation is reduced which, in turn, leads to a reduction in the motion of the building. (Tr. 9333). It can be looked upon as an "engineering equivalent" such as is traditionally used for various loadings and conditions as, for example, wind forces, rail and truck loadings on bridges, live loads on building floors, current forces on wharves and docks, etc. There is ample evidence of the excellent performance of large building foundations in earthquakes. Tau is a manifestation of this. The larger the foundation and the shorter the traveling wave length, the more effective is the so-called tau reduction. The values of tau determined by Dr. Newmark and Dr. Blume varied slightly due to different approaches as did the zero-period accelerations associated with the tau-factor for each structure. However, whichever was more conservative controlled for the analysis. (Blume Testimony at 42-43).

"Damping" is related to the energy change during vibration and it varies for different materials and structures. Energy is never lost but it changes form. The kinetic energy of motion of a vibrating body or system is reduced by energy converted to heat through friction and the internal stressing or materials, and by other means. The rate or degree of this loss is called damping. If there were no damping at all, an oscillating system would never stop. In earthquake analysis viscous damping is generally assumed, and it is given as a ratio to or percentage of critical damping which is that damping value which would prevent oscillation altogether. (Blume Testimony, 3-4. See also Newmark rebuttal at Tr. 9298-9300). Damping values were reconsidered by the NRC in the period between the original design of Diablo Canyon and the discovery of the Hosgri. While 5% damping was actually used in the original design of structures, Regulatory Guide 1.61 permitted the use of 7% at the time of the Hosgri analysis, and that figure was used. (Blume Testimony 14-15).

Dr. Luco alleged that Applicant's soil structure interaction analysis (J.I. Ex. 58) showed that there was no tau effect at Diablo. (Tr. 8923-926). Applicant stated that its study showed nothing about tau at all as it was not designed to show tau effects (or the lack thereof). (Tr. 10,151). While various experts' methods of applying tau may be different, (Tr. 6807) tau effects result primarily from the fact that the wave motions are not all perfectly vertical as they approach a foundation slab and they are also due to nonhomogeneity of the soil or rock formations on which the foundation is constructed. (Tr. 10,151). In rebuttal to Dr. Luco, Dr. Seed showed how the tau effect for Diablo can be derived by waves arriving at less than perfectly vertical (PG&E Ex. 64, Tr. 10,152-160) and by nonhomogeneity of the rock structure upon which the foundation rests. (PG&E's Ex. 65, Tr. 10,162-10, 166). Dr. Newmark's rebuttal also pointed out the deficiency in Dr. Luco's analysis on tau effect stating that Dr. Luco improperly assumed coherence of high frequency motions that affect the reactor. (Tr. 9278).

In conclusion, Dr. Seed testified that the tau reduction used by Drs. Blume and Newmark was both justified and scientifically defensible. (Tr. 10,167). Dr. Newmark testified that the variation in acceleration over an area is the tau effect. It has to do with the ground which is inhomogenous and scattering takes place. There would be differences in phasing, resulting in differential values over the area, no matter whether the wave approaches from the bottom, from the side, from the middle or other direction. The tau effect is only a way of trying to account for this in some systematic and reasonable fashion. (Newmark Testimony, Reference B at 11-12 and Figs. 1-2).

The Board finds that the reductions for tau for various response spectra from the .75g zero period of the basic response spectrum are justifiable and adequately conservative.

Dr. Blume discussed the damping values prescribed in NRC Regulatory Guide 1.61 (7% for structures) and the additional data developed because these values had been questioned. Two facts were particularly important: elements with friction between parts, such as bolted steel joints or concrete with minor cracks, have considerably greater damping at a given strain level than where such friction is not possible, as for example in welded joints or in uncracked concrete; damping increases with strain or deformation. Another consideration is that a structure not only receives energy from the moving ground but returns some of it to the ground, which is often termed radiation damping. No credit for this type of damping was taken for the Diablo units. Another point is that it is not necessary to develop high strain levels throughout an entire structure to develop high damping levels; local high strain levels can be quite effective in absorbing the kinetic energy of motion, as shown by test results presented by Dr. Blume. Based upon all of this, Dr. Blume concluded that 7% of critical damping was conservative for the Diablo Canyon structures subjected to the hypothetical Hosgri earthquake, and that the value could be as high as 8% to 10% for the postulated Hosgri event. (Blume Testimony at 47-49).

Finally, Dr. Blume stated that the response spectra and damping values were applied to each structure as appropriate to obtain the moments, shears, axial forces and stresses at various points in the structures. This was done by others and the results were provided in terms of the stresses obtained as compared to the stresses allowable under NRC regulations. In a small number of cases "over-stresses" were found and physical alterations are being made to the structures involved so as to meet all the criteria. In addition "floor response spectra" were developed to represent the amplified motion at upper levels where piping or equipment is attached or anchored. (Blume Testimony at 49-50).

Dr. Newmark testified that the design criteria for the Diablo Canyon Reactor, based on the original concept for design and the retrofit proposed, when reviewed in the way that it was reviewed, and looked at by a number of people on the staff and in various consulting firms employed to make the review, results in a design which is more adequate than that of most of the other reactors that have not undergone this intensive audit. He testified that major conservative assumptions were made and that the state-of-the-art of nuclear reactor design as reflected in current practices gives an adequately conservative design. (Newmark Testimony, Reference B, p. 17).

Dr. Newmark rebutted Drs. Luco and Trifunac, stating that what the knowledgeable design engineer seeks in designing structures for dynamic loads is adequate strength combined with ductility and energy absorbing capacity rather than excessive strength and its concomitant brittleness. Dr. Newmark took into account all of the written and orally expressed opinions of Drs. Luco and Trifunac and did not have any reservations about the adequacy of the seismic design for the Diablo Canyon nuclear power plant. (Tr. 9304-05).

Dr. Newmark would have no hesitancy today in recommending that the Diablo Canyon Plant be built at the site where it is located. (Tr. 9308).

Finally, Dr. Trifunac, called by Intervenors, testified that the structures within the complex of the plant (Diablo Canyon) are reasonably designed to withstand a reasonable earthquake on the Hosgri Fault; reasonable earthquake being a spectrum of possible events which are physically capable of happening there. (Tr. 9198-199).

The Board concludes that the response spectra used by the Hosgri seismic evaluation were appropriate and conservative. The use of these spectra in the reevaluation of the plant for the postulated Hosgri event reasonably assures the preservation of the health and safety of the public.

The seismic input, once defined, is used in a mathematical process to determine how the structure would vibrate in response to the seismic shaking. In order to perform this operation, the structures are characterized in a mathematical model by means of the mass of the major parts (floors, walls, domes, etc:) and the stiffness of the connections between these parts. The stiffness is usually characterized as a spring, and we therefore commonly speak of a spring-mass model. (Knight Testimony at 2).

Through the use of proven and common principles of applied mechanics and mathematics, the response of each of the major portions of the structure, as well as the response of the structure at the mounting location of safety-related systems and components, can be defined for design purposes. (Ibid.)

Throughout this process, the characterization of very complex structures by fundamental characteristics, such as mass and stiffness, requires idealization of the various structural parts. Because of this, a principal part of the engineering practices involved is the use of techniques which yield a conservative estimation of the various physical quantities being represented. In the analytical process these physical quantities interact in complex ways. In order to achieve overall conservatism, it is standard engineering practice to establish a conservative quantity at each stage in the analytical process. The results obtained are therefore recognized as very conservative, but prudent, until such time as a more complete understanding of the interaction between the various quantities is obtained. (Knight Testimony at 3).

The design of the various structural parts is then based upon the results of the design analyses. There is a common misconception that the design of the structural elements is such that the capacity of those elements just meets the requirements called for by the analyses. In fact, much of the structural design is controlled by the size of standard structural members such as reinforcing rods and beams, and construction requirements such as access to make large concrete pours. In addition, engineering codes specify "code minimum strength" for materials. These code minimum strengths are in turn specified by the applicant when the materials are ordered; any material found to be under that strength is rejected. The result is that the material supplier, in order to assure that he stands no risk of having costly material returned, provides material of considerably higher strength. These higher strengths are borne out by the mill test reports for steel and concrete cylinder tests. There is normally no motivation to go back and assess the true strength of various structures, systems and components, because of the costs of reanalysis and time lost swamps any reduction in size or equipment capabilities that may be gained. (Ibid.).

In the design of structures and equipment, it is convenient in typical engineering analyses to assure that all elements of the structure or equipment remain elastic or nearly so, i.e., stresses below the yield point of the material so that any permanent deformation is very small. One of the principal reasons for this is that the maintenance of elasticity negates the need for complex interaction analyses to determine margin to failure. From the standpoint of function, major structures and components in nuclear plants, as well as in other commercial applications, can tolerate much inelastic deformation and typically loss of numerous structural members. This deformation and loss of structural members can be sustained because of redundancy, i.e., more than one path available to carry loads and load sharing or redistribution, i.e., the load formerly carried by a failed member is redistributed to other members. (Knight Testimony at 4).

The end result of the conservatisms employed in the analyses followed by the conservatisms resulting from standard design practices is a structure with a seismic capability well in excess of the established design goal. This is the reason that the record is replete with cases where well-engineered structures, even those for which no specific seismic design standard was invoked, have withstood major earthquakes while remaining fully functional. (Ibid.) The testimony above spoke of the numerous conservatisms accruing as a result of the use of standard structures, shapes, sizes and materials. A very analogous phenomena occurs in the testing of the equipment and components. In order to assure fully representative testing with respect to both direction and characterization of vibratory input, a given piece of equipment is subjected to a large number of individual tests, any one of which often equals or exceeds the most likely vibration to be seen by the equipment in any actual earthquake. The number of tests typically range from 10 to 50 before a program for an individual piece of equipment is completed. In this way the question of aftershock or marginal performance of prototype equipment that may not be fully characteristic of installed equipment is adequately addressed. Clearly, the history of vibratory loading established during the test program exceeds even the most pessimistic view of possible effects of aftershock loading. Any concern that some fatal flaw that may hinge on a subtlety in fabrication or installation may not be discerned by a single shaking has to be put aside. In addition to the number of tests employed, the magnitude of tests, once again, due to the practicalities of designing tests equipment to meet myriad test requirements, always exceeds that required (already conservatively defined by virtue of the structural analyses). (Knight Testimony at 5).

The Hosgri seismic evaluation considered and has established the capability of all Diablo Canyon structures, systems, and components designated as Design Class I, which corresponds directly to "Category I" as originally used in Safety Guide 29. Safety Guide 29 was subsequently reissued as Regulatory Guide 1.29, which, in turn, was subsequently revised twice. The Diablo Canyon classification system also meets the intent of the latest revision of this regulatory guide. In some instances, since Diablo Canyon structures, systems, and components were assigned seismic design classification prior to the issuance of definitive guidance by the Regulatory Staff, some systems and components were classified as Design Class I which would not be required to be designated Category I by current regulatory practice. Certain structures, such as the turbine building, which were not designated as Design Class I but whose failure could affect the functioning of Design Class I structures, systems, and components have been treated as Design Class I for the purposes of the Hosgri seismic evaluation. Set forth in greater detail in witness Hoch's testimony are the structures, systems, and components considered in the Hosgri seismic evaluation, the criteria and methodology employed, the tests and analyses made and the manner in which concurrent functional operational and accident-induced loads were taken into account. (Hoch Testimony at 15-21).

Concerning Contention 7, for Diablo Canyon structures the acceptance criteria employed in the Hosgri seismic evaluation allowed stresses or strains beyond yield only in very limited situations and under conditions where such yielding could not affect the performance of necessary safety functions. Only in a very few locations in Diablo Canyon structures did the results of the Hosgri seismic evaluation indicate stresses beyond the yield point of the material. These included the curtain wall of the intake structure, localized end bents of the turbine building if a crane is parked at either end of the building, and certain piers beneath the main turbine generators. The associated deformations were evaluated to assure that all necessary safety functions are maintained. (Hoch Testimony at 21, 22; Tr. 6917).

For those components qualified by test for the postulated Hosgri event, functionality was demonstrated during the test as well as after the test if such functionality was required in order for the component to perform its intended safety function. For equipment qualified by analysis which must move, open or close, pump fluids, or otherwise perform an active safety function when subject to seismic loadings, special criteria were developed and applied to assure that deformations as a result of seismic loadings would not prevent performance of the active safety function. (Tr. 6919-6921). For certain Diablo Canyon components, such as piping systems, the acceptance criteria for stresses employed in the Hosgri evaluation were in accordance with accepted industry codes and standards. For loading combinations associated with a Safe Shutdown Earthquake, these acceptance criteria do, indeed, allow calculated stresses (or strains) beyond the yield point of the material. These codes and standards, and the stresses allowed, are drawn from extensive experience with the piping systems and materials involved and are specifically formulated to assure that when stresses calculated by code approved methods are at or below allowable, the necessary integrity of the piping system will be maintained. (Hoch Testimony at 22, 23).

Wherever the Hosgri seismic evaluation showed that stresses or strains beyond the yield point would be calculated for loading combinations related to the postulated Hosgri event, all necessary safety functions will be maintained and the plant complies with all applicable NRC Rules and Regulations, including that portion of Section (VI)(a)(1) of Appendix A to 10 CFR Part 100 related to Intervenor's contentions. (Hoch Testimony at 23).

Evidence was presented to support the conclusion that the structures, systems and components will perform as required during the postulated earthquakes, i.e., they will remain functional and within applicable stress and deformation limits when subjected to the effects of the vibratory motion of the postulated Hosgri event, including appropriate concurrent loads. The Design Class I structures include the containment structure, the auxiliary building, and the outdoor storage tanks. The Design Class II structures containing Design Class I components include the turbine building and intake structure. (Ghio Testimony following Tr. 6941 at 1-3, 8-10).

Witness Ghio reviewed the procedures followed in establishing the original seismic design of the plant using postulated earthquakes and criteria approved by the Atomic Energy Commission with the issuance of construction permits for the units. Mr. Ghio then summarized the seismic evaluation of the plant for the postulated 7.5M Hosgri earthquake and various intermediate postulated earthquakes and the criteria developed to effect this. Documentation for this evaluation was set forth in the Hosgri Report. In April 1976 the NRC Staff issued Supplement No. 5 to the SER, which included response spectra independently derived by Dr. N. M. Newmark, the rationale for their development as well as the parameters to be used in the foundation filtering calculations for each major structure. Supplement No. 5 prescribed that either the spectra developed by Blume or Newmark would be acceptable with the following conditions:

(i) In the case of the Newmark spectra, no reduction for nonlinear effects would be taken except in certain specific areas on an individual case basis;

(ii) In the case of the Blume spectra, a reduction for nonlinear behavior using a conservative factor may be employed;

(iii) The results determined by use of the Blume spectra would be adjusted so as not to fall below the results determined by use of the Newmark spectra at any frequency. (Ghio Testimony at 10-14).

Mr. Ghio explained that the basic approach used in the Hosgri evaluation of structures adopted the same analytical procedures and criteria which were employed for the original seismic analysis, with the following specific changes:

1. Use of the new 7.5M on Hosgri inputs.
2. Use of Regulatory Guide 1.61 damping.
3. Use of actual material properties (excluding allowance for concrete gain in strength with age).
4. Allowance for ductility in certain cases.
5. Use of fixed base mathematical models.
6. Vertical response dynamic analysis or equivalent.
7. Use of accidental torsion or equivalent in addition to geometric torsion.
8. Modified procedure for smoothing floor spectra.

9. Combination of horizontal and vertical responses on 3-component square-root of the sum of the squares basis (or equivalent). (Ghio Testimony at 14, Tr. 6945; 6946.

The containment structure has been qualified, with minor modifications which have been implemented, for the postulated Hosgri earthquake. Likewise, the auxiliary building, with modifications to improve the seismic shear distribution in the fuel handling area, qualifies the structure for the Hosgri event. The Design Class I outdoor water storage tanks required significant modifications to permit them to resist the Hosgri earthquake. Similarly, the turbine building required substantial structural modifications to resist the Hosgri event. The intake structure has been found capable of resisting the Hosgri earthquake without sustaining any damage that would impair the functioning of the auxiliary saltwater pumps. (Ghio Testimony at 3-8; Tr. 6943, 6944). Subsequent panels presented detailed information concerning the modifications of these various structures: containment (Ghio-Malik Testimony at 1-8; Tr. 6994-7031, 7040-7125); auxiliary building (Ghio-Malik Testimony following Tr. 7130 at 1-6; Tr. 7131-7174); turbine building (Ghio-Lang Testimony following Tr. 7181 at 1-6; Tr. 7182-7219); intake structure (Ghio-Lang Testimony following Tr. 7224 at 1-4; Tr. 7225-7269); outdoor water storage tanks (Ghio-Jhaveri Testimony following Tr. 7285 at 1-4; Tr. 7287-7309, 7404-7419); and buried tanks and piping systems (McLaughlin-Lawson Testimony following Tr. 7324 at 1-4; Tr. 7325-7352).

Similar evidence was presented concerning the integrity of plant mechanical and electrical systems in the event of a Hosgri earthquake to assure:

(i) the integrity of the reactor coolant pressure boundary

(ii) the capability to shut down the reactor and maintain it in a safe condition, and

(iii) the capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to the guideline exposures of 10 CFR 100.

The following general classes of components were included in the Hosgri requalification: reactor coolant system; auxiliary mechanical equipment; piping systems other than the reactor coolant piping; and electrical equipment. The process that was used for the requalification of the mechanical and electrical equipment for the Hosgri earthquake was broken down into seven basic steps:

1. Identification of systems requiring evaluation.
2. Definition of the functional requirements of the equipment within the required system.
3. Determination of the seismic input to the required system.
4. Establishment of the criteria for evaluation.
5. Establishment of the methodology of the evaluation.
6. Perform the evaluation, determine the need for modification.
7. Make modifications where required.

Each of these steps in the requalification process will be described in more detail below. (Gormly Testimony following Tr. 7449 at 1-3; Tr. 7450, 7451).

As discussed in Mr. Ghio's testimony, seismic response spectra for all relevant locations in those structures significant to the plant were developed by URS/John A. Blume & Associates. These spectra are contained in Chapter 4 of the Hosgri Report and provided in the seismic input for the qualification of the equipment of concern. To determine the systems requiring evaluation, those required for plant shutdown were identified first. Next, the systems and procedures required to achieve and maintain hot shutdown and long-term cold shutdown conditions after the postulated seismic event were evaluated. This evaluation was consistent with Regulatory Guide 1.29 and was done assuming that:

1. only systems qualified for the event would be available;
2. the single failure criterion would be satisfied;
3. off-site power may be lost for an extended period of time.

A tabulation was then made of the equipment and components comprising those systems and the functions that the equipment was required to perform. This included a determination of whether components were passive or were required to mechanically function during or following the postulated seismic event. Also, piping systems which were required to retain their structural integrity were identified. Equipment not required for shutdown but which would be categorized Category I by current regulations was further identified. Stress criteria were developed for various components. For components which were required to perform a mechanical function in addition to retaining their structural integrity, additional criteria were developed. The appropriate criteria were established in conformity with the applicable industry codes and standards as required by 10 CFR 50.55a. The criteria for mechanical equipment and piping were taken primarily from the ASME Boiler and Pressure Vessel Code and the criteria for electrical equipment were taken from IEEE standards. After the equipment and systems of concern were identified and specific criteria were fixed for such equipment and systems, the specific evaluation commenced. The evaluation was accomplished by either detailed seismic analyses, seismic testing (shaking), or a combination of analyses and testing. The details of the analyses or tests performed for this equipment can be found in Chapters 5 through 10 of the Hosgri Report. The results of the analyses and/or tests were then compared to the criteria developed for acceptability. For instance, the results of a seismic analysis would define the stresses developed in the component from the postulated seismic event. These seismic stresses were then combined with other stresses which would be caused by normal operation or, where appropriate, stresses that would be caused by design basis events. The total stress was then compared to the stress criteria. Where the stresses exceeded the stress criteria, an evaluation was made as to the action required to satisfy the stress criteria, such as equipment modification or replacement. (Gormly Testimony at 2-5; Tr. 7452-7467).

In general, the major area where significant plant modifications were required by the requalification was in the piping systems. As a result of stress analyses, modifications have been made to at least 900 of the approximately 5,000 pipe supports, the remaining 4,100 not requiring modification. (Tr. 7679). These modifications range from a minor stiffening of the support to complete replacement. In no instance was it necessary to modify or replace the piping itself. In addition to the piping system modifications, some modifications were required for approximately 50 percent of the above-mentioned tanks and heat exchangers. These modifications were generally minor and were related to increasing the support capacity. Other modifications were made in various electrical components in the plant. (Gormly Testimony at 6). Detailed evidence concerning the analyses and modifications, if necessary, of various systems and components was offered covering plant systems (Gangloff Testimony following Tr. 7471 at 1-8; Tr. 7472-7484); the reactor and reactor coolant system (Esselman Testimony following Tr. 7548 at 1-8; Tr. 7549-7586); auxiliary mechanical equipment (Esselman-Antiochos Testimony following Tr. 7589 at 1-6; Tr. 7590-7657; other piping systems (Bacher-Esselman Testimony following Tr. 7660 at 1-7; Tr. 7661-7679); and electric equipment and instrumentation (Esselman and Young Testimony following Tr. 7686 at 1-8; Tr. 7687-7692).

With regard to the reactor and reactor coolant system, the analysis demonstrated the ability of the reactor and reactor coolant system to withstand the postulated Hosgri event coupled with a simultaneously occurring postulated pipe break in the main reactor coolant piping. The NRC Staff required that the stresses or loads resulting from the postulated seismic event be combined with the stresses or loads resulting from the postulated pipe rupture. The results of the combination of the stresses and the overall stress summary are presented in Appendix F of the Hosgri Report. This appendix demonstrates the acceptability of the reactor coolant system. It is important to note that the allowable stresses used are determined by various Codes and Standards groups to assure the structural integrity of the structure or component. Thus, as long as the stresses are determined to be equal or less than allowable, there is ample margin in the design of the system. The acceptance criteria used provide substantial additional margin to failure. (Esselman Testimony at 4-5).

The reactor fuel for Diablo Canyon, described in Chapter 4 of the FSAR, could conceivably be affected by the postulated seismic event combined with the loss of coolant accident. As a result of a seismic event, the motion input to the fuel would cause impact loads on the fuel grids. The fuel grids are spacer elements which maintain the spacing of the fuel rods to permit adequate cooling. Dynamic testing was performed on the grids to determine the load at which they would first experience permanent deformation. Loads from the seismic event and the worst postulated loss of coolant individually and combined, are below the allowable grid strength. This provides assurance that the fuel grids will not deform and that the geometry for adequate cooling will be maintained following the postulated Hosgri event and a concurrent loss of coolant accident. The NRC Staff did, however, request that fuel grid deformation be postulated. Assuming fuel grid deformation, the resultant modification geometry of the grid was used in an ECCS analysis. It was demonstrated that with the postulated maximum credible deformation of the grid, the core would remain coolable. The fuel was, in short, shown to be acceptable by two different methods:

(i) The calculated loads indicated that deformation of the fuel grid would not occur; and

(ii) even if the postulated maximum credible deformation occurred, that the core would remain in a coolable geometry.

Accordingly, the entire reactor coolant system has been shown to be fully acceptable for the postulated seismic event and the unlikely simultaneous occurrence of a postulated pipe break event. Thus the integrity of the reactor coolant pressure boundary is assured. (Esselman Testimony at 5-7; Tr. 7571-7576, 7582, 7583).

At various stages in the presentation on mechanical systems and components, questions were asked of PG&E and Staff witnesses concerning simulated aging. It developed that the updating to current criteria required by the NRC Staff did not include simulated aging and other general environmental qualification recommendations reflected in the Staff's current position for new plants. (Tr. 7461, 7463, 7648, 7845, SER Supp. 7 pp. 3-72). It was pointed out that aging need not be considered for the reactor coolant system and auxiliary mechanical equipment because those materials do not age. (Tr. 7578,-7580, 7583, 7584, 7641-7646, 7648). It was also pointed out that aging of such equipment is taken care of automatically through such measures as designing against corrosion or other degradation. (Tr. 7646, 7647). Finally, most of the remaining power plant components in question are not unique to nuclear power plants and a lengthy record of preventive maintenance to offset the effects of aging for the life of the plant has been developed through the years at fossil-fueled stations. (Tr. 8790).

Intervenors offered testimony on Contentions 5, 6 and 7 through their witness Richard B. Hubbard. (J.I. Ex. 65). As with his testimony on the operating basis earthquake, much of his testimony was struck as being beyond the expertise of the witness. (Tr. 7888-7893). Of the testimony remaining, there were allegations that there is no record that the effects of aging have been considered in the seismic qualification of electrical equipment and that using a shaker table may have introduced common failure modes not readily detectable. (J.I. Ex. 65, pp. 5, 6, 7-8). However, on cross-examination, Mr. Hubbard admitted that the IEEE standard which refers to aging was not issued until 1974 and that the prior version of the IEEE standard, issued in 1971, did not have a requirement for simulated aging. (Tr. 7895, 7896). He also admitted that the effects of aging could be determined through periodic testing and inspection. (Tr. 7899, 7900). As far as the use of the shaker tables is concerned, Mr. Hubbard admitted that the absence of such testing of the plant components would give rise to uncertainties, different uncertainties, than if the components were so tested. (Tr. 7913-7916). An NRC Staff witness testified that equipment must be qualified both during and after the simulated event and that, accordingly, PG&E was required to inspect and test the equipment to demonstrate functional operability after the test. In addition, the Staff took one more step than ordinarily required by requesting PG&E to install strain gauges on some of the equipment to measure stress incurred during the test and possible fatigue. The data indicate that the structural integrity of the equipment will not be affected by possible fatigue due to the shaker table testing and therefore it is acceptable to return the equipment to the plant. (Tr. 8711, 8713; 8813-8816). Another

NRC Staff witness pointed out that in all cases only one of a redundant set of equipment was so tested. (Rosa Testimony, p. 8).

NRC Staff review of the structures, systems, and components of the Diablo Canyon Plant was described in the SER Supplements 7 and 8 and in testimony by a panel led by Mr. James P. Knight. (Testimony following Tr. 8697). Mr. Knight explained the methods and procedures followed by the Staff in reviewing the facility for the Hosgri event, and he described the major modifications made to the existing plant facilities to quality them for the Hosgri event. He concluded as follows:

> The Staff review of the seismic design of the DCNGS has been the most extensive we have ever undertaken. This review has extended from the basic input criteria employed through the details of myriad analyses to the implementation in final design. Our goal throughout the review has been to assure that demonstrably conservative practices were followed at each level of design. We believe that this goal has been fulfilled in all aspects of the DCNGS reevaluation, including confirmatory analyses and tests, design of modifications, and the establishment of operating restrictions where necessary. It is our conclusion, therefore, that the structures, systems and components necessary at the DCNGS to asure the health and safety of the public will remain functional under the loading that would result from any seismic event of severity up to and including that specified for the Hosgri event.

Testimony as to the seismic qualification of the Class I electric equipment was presented by NRC Staff witness Faust Rosa. (Testimony following Tr. 8748). He also testified concerning aging, noting there previously had been no such requirement but that did not make nuclear plants unsafe because there are other things going on continuously that would reveal the effects of age, such as seismic testing and normal maintenance. (Tr. 8785, 8786). The Staff, nevertheless, is conducting research programs and a systematic evaluation of older operating reactors to better determine the significance of aging in qualification testing. This subject will be reassessed by the Staff before natural aging could have any significant effect on the seismic qualification of equipment installed at Diablo Canyon. (Rosa Testimony at 6-7). It was also pointed out that there is nothing unique about most of the equipment in a nuclear power plant and that a wealth of experience exists with this equipment in facilities around the world which have been in existence the past ten, twenty or more years. (Tr. 8790).

The Staff review of the seismic design of the Diablo Canyon plant was the most extensive ever undertaken by the Staff of the NRC. (Knight Testimony at 54). The Applicant's review was also extraordinarily thorough.

The Board finds that the Applicant has demonstrated through appropriate analysis and tests that Category I structure, systems and components will perform as required during the seismic load of the safe shutdown earthquake.

The Board finds that the Category I structures, systems and components will be adequate to assure (a) the integrity of the reactor coolant pressure boundary, and (b) the capability to shut down the reactor and maintain it in a safe condition.

The Board finds that the evidence demonstrates that all structures, systems and components of the Diablo plant necessary for continued operation without undue risk to the health and safety of the public will remain functional and within applicable stress and deformation limits when subjected to the effects of the operating basis earthquake in combination with normal operating loads.

The Board finds that the necessary safety functions will be maintained during the safe shutdown earthquake where, in safety-related structures, systems and components, the design for strain limits is in excess of the yield strain.

IV. THE SECURITY PLAN REVIEW

Intervenors, San Luis Obispo Mothers for Peace, through other counsel also advanced a contention covering various ways in which PG&E's security plan allegedly fails to conform to NRC regulations. Due to the inability to produce a qualified expert as mandated by the Appeal Board in ALAB-410, Intervenors in a letter dated January 19, 1979, withdrew from the proceeding, and the Board accepted the letter as a voluntary default under 10 CFR 2.707. (Tr. 9367-9368). The Applicant and Staff requested the Board to proceed with a review of the security plan and the Board acquiesced. At a special <u>in camera</u> session before the Board on Monday, February 12, 1979, Staff and Applicant presented evidence that PG&E's security plan in fact complies with all applicable NRC Regulations. On the same date, the Board members together with Applicant and Staff counsel and witnesses also toured the Diablo Canyon plant to view the security system and components. Based upon the evidence presented the Board finds that the

PG&E security plan complies with all applicable NRC regulations. Because of the sensitive nature of this evidence, it will not be further reviewed in this Partial Initial Decision.

In this Partial Initial Decision there can be no Conclusions of Law or Order. The Board has determined that it is appropriate to remind the parties that the Appeal Board may entertain exceptions to this Partial Initial Decision. If that is the case, exceptions may be filed by any party within 10 days after the service of this Partial Initial Decision. A brief in support of the exceptions should be filed within 30 days thereafter (40 days in the case of the Staff). Within 30 days after the service of the brief of appellant (40 days in the case of the Staff) any other party may file a brief in support of, or in opposition to, the exceptions.

THE ATOMIC SAFETY AND
LICENSING BOARD

William E. Martin

William E. Martin, Member

Glenn O. Bright

Glenn O. Bright, Member

Elizabeth S. Bowers

Elizabeth S. Bowers, Chairman

Dated at Bethesda, Maryland
this 27th day of September 1978.