May 11, 1976

SUPPLEMENT NO. 4

TO THE

SAFETY EVALUATION REPORT

BY THE

OFFICE OF NUCLEAR REACTOR REGULATION

U.S. NUCLEAR REGULATORY COMMISSION

IN THE MATTER OF

PACIFIC GAS AND ELECTRIC COMPANY

DIABLO CANYON NUCLEAR POWER STATION, UNITS 1 AND 2

DOCKET NOS. 50-275 AND 50-323

B/31

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APPENDICES

1.0 INTRODUCTION

The Commission's Safety Evaluation Report in the matter of the Diablo Canyon Nuclear Power Station, Units 1 and 2, was issued on October 16, 1974. In the Safety Evaluation Report it was stated that supplemental reports would be issued to update the Safety Evaluation Report in those areas where the staff's evaluations had not been completed. Supplement Nos. 1, 2 and 3 to the Safety Evaluation Report, issued on January 31, 1975, May 9, 1975, and September 18, 1975 respectively, documented the resolution of several outstanding items, and summarized the status of the remaining outstanding items.

The purpose of this supplement is to further update the Safety Evaluation Report by providing the staff's evaluation of certain matters which were not resolved when Supplement No. 3 was issued. Each of the following sections of this supplement is numbered the same as the corresponding section of the Safety Evaluation Report that is being updated.

Appendix A to this supplement is a continuation of the chronology of the Nuclear Regulatory Commission staff's principal actions with respect to radiological matters related to the processing of the application. Appendix B is a bibliography. Appendix C is a report by the U. S. Geological Survey dated April 29, 1976.

2.0 SITE CHARACTERISTICS

2.5 Geology, Seismology and Foundation Engineering

In Supplement No. 1 to the Safety Evaluation Report, we described our review of Amendments 11, 19 and 20 to the FSAR. At that time we stated that our evaluation of the earthquake potential of the Hosgri fault zone was continuing. This supplement presents our review of investigations performed by the applicant since then which are documented in Amendments 31, 32, 34, 37 and 40 to the FSAR. These amendments responded to a request for information in our letter dated February 12, 1975. That letter requested additional information and investigations relevant to determining the earthquake potential of the Hosgri fault zone as follows:

(1) Provide additional discussion and arguments for determining the maximum earthquake that can be expected on faults of various ranks within the San Andreas system. Relate the discussion to historic seismicity.

(2) Provide additional documentation, including seismic reflection profiles, on the intersection of the Hosgri fault zone with the Transverse Range faults. Include geologic maps southward of those provided in the PSAR showing the structural relationships of the Transverse Range faults and structures having northwest trend.

(3) Provide additional documentation, including seismic profiles, on the northern reaches of the Hosgri fault zone. Include a fuller development of views on the structural relationship of the Hosgri fault to the San Simeon fault.

(4) Provide additional information on the location of the 1927 earthquake, together with its probable mechanism. Discuss probable relationships of this event to the geologic structure in the region.

(5) Provide an evaluation of the maximum credible earthquake on the Hosgri fault zone. Assuming this event occurs, along the segment of the Hosgri fault zone nearest the site, evaluate its response spectrum at the site and compare it with the design response spectrum.

An independent interpretation of the applicant's data together with data obtained from other surveys was made by the U. S. Geological Survey. The Survey's review of the applicant's investigations, which is based in part on independent interpretations, is presented in Appendix C to this supplement.

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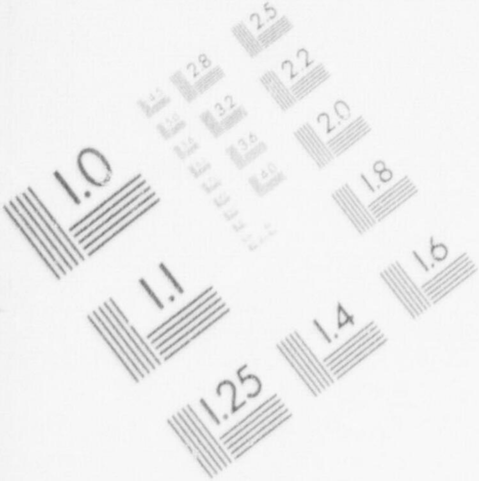

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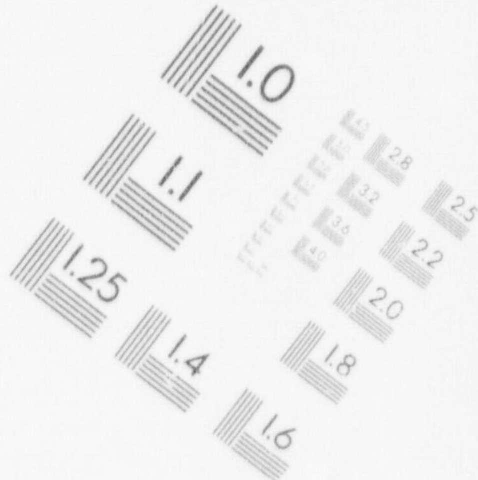

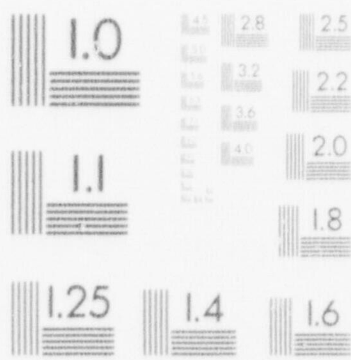

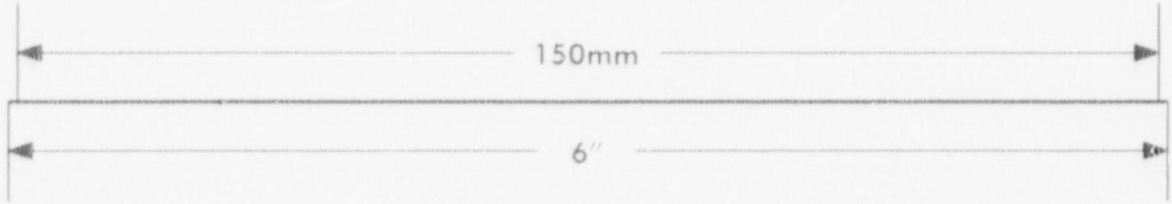

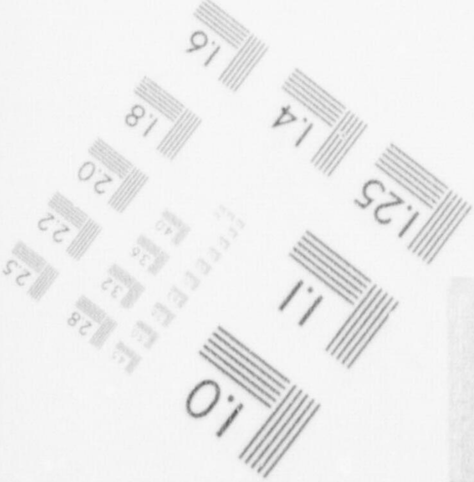

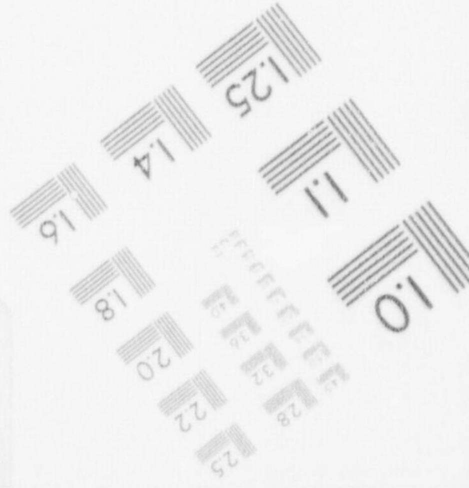

IMAGE EVALUATION
TEST TARGET (MT-3)

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Background

In 1971, two geologists with the Shell Oil Company published previously proprietary data indicating the presence of a 90 miles long fault about 4 1/2 miles offshore from the Diablo Canyon plant site (Hoskins and Griffiths, 1971). This fault and other basin boundary faults offshore were indicated as being possibly important in developing offshore oil reserves. In the operating license application submitted in 1973, the applicant cited the Hoskins and Griffiths reference and provided a map showing their location of the fault offshore of the plant site. As this represented new information not reviewed during the construction permit licensing phase, we requested that the applicant conduct an investigation of the fault sufficient to determine whether it should be considered capable within the meaning of Appendix A to 10 CFR Part 100.

At that time, the U. S. Geological Survey was also conducting reflection surveys in the area as part of a large exploration of offshore geologic structure along the California coast funded by the Commission. Their investigations resulted in the discovery of an apparent fault offset of the sea floor offshore from the Diablo Canyon plant site.

The applicant undertook high resolution seismic reflection surveys in the near offshore region to supplement the U. S. Geological Survey investigations and to determine the structural characteristics and tectonic significance of the offshore faulting. Those investigations were reported in Amendments 11, 19 and 20 to the FSAR.

As a result of our review of these Amendments, which was reported in Supplement No. 1 to the Safety Evaluation Report, dated January 31, 1975, we concluded the following:

(1) The offshore fault (by then named the Hosgri fault) locally offsets Tertiary and pre-Tertiary rocks with apparent vertical offsets between 1500 and 6000 feet and is discontinuous and segmented in the late Tertiary and Quaternary section.

(2) The style of deformation on the fault zone is predominately extensional. The Tertiary section exhibits down to the basin normal faulting; a component of strike-slip movement is apparently present in the upper section, however.

(3) Offsets of post-Wisconsinan sediments and locally the sea floor show the fault to be capable within the meaning of Appendix A to 10 CFR Part 100.

In responding to our request for additional investigations, dated February 12, 1975, the applicant conducted extensive seismic reflection surveys to determine the structural relationships between the San Simeon and Hosgri fault north of the site and the Transverse Range faults and Hosgri fault south of the site. In addition, existing deep penetration seismic reflection data were obtained from Western Geophysical Company and incorporated into the data base.

The structural relationship of the Hosgri fault and San Simeon faults is discussed in Amendment 31 to the FSAR. The applicant's interpretation of the available data shows a continuation of the Hosgri fault and its branches north of the region of possible intersection with the San Simeon fault between Cambria and Point Estero. This interpretation is consistent with that of the U. S. Geological Survey and tends to support the Hoskins and Griffiths interpretation that the Hosgri and San Simeon faults are parallel to each other. The U. S. Geological Survey considers the data inadequate to preclude intersection of the Hosgri and San Simeon fault zones, but finds the overall tectonic style of this area to be one of branching or en echelon faults (see Appendix C to this supplement).

The structural relationship between the Hosgri fault zone and the Transverse Range structures is also discussed in Amendment 31. The applicant's interpretation shows the Hosgri fault zone to trend eastward into the Transverse Range structures between Point Sal and Point Arguello. The independent interpretation of the U. S. Geological Survey extends the zone at least five miles south of Point Arguello some 20 miles beyond the southern terminus proposed by the applicant.

The contemporary sense of movement on the Hosgri fault zone was previously discussed by the applicant and the staff's review was reported in Supplement No. 1 to the Safety Evaluation Report. Additional discussions are presented in Amendments 31 and 32 to the FSAR. The applicant's investigations and Wagner (1974), both support the earlier interpretation of Hoskins and Griffiths that the fault zone experienced predominantly

vertical movement during the Tertiary. Evidence of a lateral component of movement appears to exist in some seismic profiles which show a change in the acoustical signature of one of the reflection horizons across the fault. Thus, contemporary movement on the fault zone may have a component of lateral movement or may even be predominantly lateral.

Conclusion

The U. S. Geological Survey concluded that a magnitude 7.5 earthquake could occur on the Hosgri fault. As stated in Appendix C to this supplement, the Survey's report is intended to form a basis for deriving an effective acceleration for input into the process leading to seismic design analysis (which in this case will be a reevaluation of the seismic capabilities of the Diablo Canyon Nuclear Power Station).

We have adopted the U. S. Geological Survey's assessment as a conservative representation on the earthquake potential of the Hosgri fault.

The magnitude 7.5 earthquake on the Hosgri fault is to be considered in addition to the earthquakes considered previously in the construction permit application. Those earthquakes which were considered previously and for which the plant's design has already been found acceptable are as follows:

(1) Magnitude 8-1/2 along the San Andreas fault 48 miles from the site.
(2) Magnitude 7-1/4 along the Nacimiento fault 20 miles from the site.
(3) Magnitude 7-1/2 along the off-shore extension of the Santa Ynez fault 50 miles from the site.
(4) Magnitude 6-3/4 aftershock near the site associated with (1).

Effective Acceleration

The ground motion values recommended by the U. S. Geological Survey are based on instrumental data insofar as possible and do not reflect the presence of structures. These values must be translated into quantitative measures of effective acceleration for design purposes. To develop an effective acceleration for Diablo Canyon, we have obtained the advice of our consultant in this area, Dr. N. M. Newmark of N. M. Newmark Consulting Engineering Services. He has recommended, and we have accepted, that an effective horizontal ground acceleration of 0.75g be used for the development of design response spectra. We will provide additional discussion of this matter, and a report from our consultant, Dr. Newmark, in a future supplement to the Safety Evaluation Report. Further discussion concerning reevaluation of the facilities is provided in Section 3.7 of this Supplement.

3.0 DESIGN CRITERIA - STRUCTURES, COMPONENTS, EQUIPMENT AND SYSTEMS

3.7 Seismic Design

In Section 3.7 of the Safety Evaluation Report we presented our evaluation of seismic design criteria, methods and procedures and we found them to be acceptable. At that time our review was based on the original seismic design bases (seismic response spectra) that were used in designing the plant and which had been approved at the construction permit stage of review. However, because new information concerning geology and seismology had come to light, we were still reviewing the seismic design bases for the Diablo Canyon plant site when the Safety Evaluation Report was issued.

Since then we have determined that, in addition to the earthquakes considered in the original seismic design bases, a magnitude 7.5 earthquake should be assumed to occur on the Hosgri fault and we have adopted an effective horizontal ground acceleration of 0.75g for the development of design response spectra (see Section 2.5 of this supplement).

At a meeting on April 20, 1976, we requested that the applicant evaluate the plant's capability to withstand such an earthquake. An outline of the procedures that we believe would be appropriate for this evaluation is as follows:

(1) A magnitude 7.5 earthquake on the Hosgri fault should be assumed with horizontal ground response spectra normalized to an effective value of 0.75g for engineering reevaluation of the plant.

(2) A revision of the design response spectra will be accepted depending on the equivalent length of the foundations of individial buildings. This revision recognizes that ground motion waves are not synchronized underneath structures during earthquakes. In other words, different points on the foundation base slab will not experience the maxima in the ground motion at the same time (see references 2 and 3, Appendix B to this supplement).

(3) Where such revision in response spectra is used, appropriate allowance for tilting and torsion, which may result from the nonsynchronized earthquake motion considered in item (2) above, will be required.

(4) In reevaluating the capability of the plant structures, systems and components, inelastic behavior may be relied upon to absorb the ground motion energy. Where such behavior is relied upon, a ductility ratio not exceeding 1.2 is acceptable in determining seismic loads and motions. For each particular structure where inelastic behavior is utilized, justification and bases will be required for assuring that the additional strains and deformations will not affect the safety functions of the plant systems and structures. The use of a ductility ratio is permissible only for near-field earthquakes, such as the earthquake postulated for the Hosgri fault.

The analytical work required to develop individual response spectra for the various plant buildings and to evaluate their response will be performed by the applicant and a report will be submitted to the Commission. We and our consultant, N. M. Newmark Consulting Engineering Services, will review the report and present our evaluation in a future supplement to the Safety Evaluation Report.

4.0 REACTOR

4.4 Thermal and Hydraulic Design

Introduction

We have reviewed the Diablo Canyon core design calculations with respect to margins to departure from nucleate boiling (DNB). These margins were discussed in Section 4.4 of the Safety Evaluation Report. We have also examined the potential penalties due to two items for which we have not completed our review, non-uniform heating tests and fuel rod bowing. By comparing the potential penalties imposed by these two items with the margins to DNB, we have determined the net impact of these items on plant operation. Our evaluation is presented below.

Effect of Non-Uniform Heating on DNB

In Section 4.4 of Supplement No. 2 and Section 4.4 of Supplement No. 3 to the Safety Evaluation Report, we stated that we were reviewing the results of DNB tests involving non-uniform heating. These results were reported in WCAP-8536 (Proprietary) and WCAP-8537 (Non-Proprietary), "Critical Heat Flux Testing of 17 x 17 Fuel Assembly Geometries with 22 Inch Grid Spacing." We also indicated that, unless our evaluation of this matter was completed by the time the technical specifications for Diablo Canyon were finalized, we would require that the minimum allowable departure from nucleate boiling ratio (DNBR) be increased by 5 percent above that required to satisfy the 95/95 criterion.

Since our evaluation of this matter is not yet completed, our position on this item remains unchanged.

Effect of Bowed Rod on DNB

In Section 4.4 of Supplement No. 2 and Section 4.4 of Supplement No. 3 to the Safety Evaluation Report, we stated that we had completed our review of WCAP-8176 (Proprietary) and WCAP-8323 (Non-Proprietary), "Effect of Bowed Rod on DNB." We had found these reports to provide an acceptable data base for predicting the effects of rod bowing on DNB heat flux for the first fuel cycle but we were reviewing additional information which had been submitted by Westinghouse concerning this effect after the first fuel cycle.

We have now completed our evaluation of that additional information and find that the reports provide an acceptable data base for predicting the effects of rod bowing on departure from nucleate boiling heat flux for all fuel cycles.

Amount of Rod Bowing

In Section 4.4 of Supplement No. 2 and Section 4.4 of Supplement No. 3 to the Safety Evaluation Report we stated that we had completed our review of WCAP-8346, "An Evaluation of Fuel Rod Bowing." We concluded that the calculational methods were acceptable for 15 x 15 fuel assemblies, based on rod bow data for 15 x 15 assemblies with seven spacer grids. We concluded that the methods were also acceptable for 17 x 17 assemblies with eight spacer grids. However, we stated that the validity of the calculation methods for the 17 x 17 assemblies must be confirmed by the continuing evaluation of data to be obtained from the 17 x 17 fuel assembly surveillance program for the two Surry reactors and the Trojan and Diablo Canyon reactors. We would review the methods as actual data became available and if necessary, make appropriate technical specification changes.

Since then, new data on 15 x 15 rod bundles with up to 31,000 megawatt days per metric ton of uranium burnup were documented by Westinghouse in the topical reports WCAP-8691 (Proprietary) and WCAP-8692 (Non-Proprietary), "Fuel Rod Bowing", dated December 1975. These data show that the bowing model presented in WCAP-8346 underestimates the extent of fuel rod bowing for both 15 x 15 and 17 x 17 assemblies and, accordingly, WCAP-8691 and WCAP-8692 present a revised bowing model.

We have not completed our evaluation of the bowing model presented in WCAP-8691 and WCAP-8692. However, based on our evaluation to date, using conservative calculations we have estimated the penalties on DNBR relative to the 95/95 criterion that would be necessary to account for the data, including an allowance for uncertainty in extrapolation of the data from 15 x 15 fuel assemblies to 17 x 17 fuel assemblies.

Conclusion

We have compared the DNB margins in the design with the penalties which we would currently apply to account for uncertainties pending completion of our evaluation of WCAP-8536 and WCAP-8537 concerning non-uniform heating, and WCAP-8691 and WCAP-8692 concerning the amount of rod bowing. Based on this comparison we have determined that the Diablo Canyon cores can be safely operated as follows: (1) First fuel cycle - no net penalty on DNBR, (2) Second fuel cycle - 1 percent net penalty on DNBR, and (3) Third fuel cycle - 2 percent net penalty on DNBR.

This is an interim position, pending completion of our evaluation of WCAP-8536, WCAP-8537, WCAP-8691 and WCAP-8692. As before, it is subject to continuing evaluation of the data from the 17 x 17 fuel surveillance program confirming the validity of the model for predicting the amount of fuel rod bowing.

We will include appropriate limitations in the technical specifications. After our review of the topical reports discussed above is complete, we will modify the penalties discussed above as appropriate. The net penalty for fuel cycles after the first cycle may be removed if warranted by the results of our review.

5.0 REACTOR COOLANT SYSTEM

5.2 Integrity of Reactor Coolant Pressure Boundary

5.2.1 Design of Reactor Coolant Pressure Boundary Components

In Supplement No. 3 to the Safety Evaluation Report, we stated that our review of the blowdown forces acting on the reactor vessel in the unlikely event of a loss-of-coolant accident at a particular location had not been completed. Although our generic review of this matter has still not been completed, we have concluded that continued licensing of facilities for operation is acceptable until we have completed our review, as described below.

By letter dated December 10, 1975, we requested that the applicant review the design bases for the reactor vessel support system for the Diablo Canyon plant to determine whether the loads discussed in Supplement No. 3 were taken into account appropriately in the design. By letter dated January 13, 1976, the applicant reported that the Diablo Canyon plant design did not specifically consider differential pressures in the annular region between the vessel and the biological shield or the transient differential pressures across the core barrel within the reactor vessel. Therefore, additional information must be submitted for our review. After we have reviewed such information we will determine what modifications to the Diablo Canyon plant, if any, are necessary to assure that acceptable margins of safety are maintained.

The results of studies reported to date on other applications indicate typically that although the margins of safety may be less than originally intended, the reactor vessel support system will retain essential structural integrity and that the ultimate consequences of this postulated accident and their potential effect on the general public are no worse than originally stated. Based on the results of our evaluation of this phenomenon to date and in recognition of the low probability of the particular pipe rupture which could lead to additional transient loads on the support systems, we conclude that reactor operation will not create undue risk to the health and safety of the public and is, therefore, acceptable pending completion of our review.

As stated above, when our review is completed we will require the applicant to make any modifications which are determined to be necessary.

6.0 ENGINEERED SAFETY FEATURES

6.3 Emergency Core Cooling System (ECCS)

In Section 6.3.3 of Supplement No. 3 to the Safety Evaluation Report, we stated that the applicant had submitted a revised analysis of ECCS performance in Amendment 33 to the FSAR. However, Amendment 33 did not contain all of the required information and our evaluation could not be completed. The applicant submitted the additional required information in Amendment 35 to the FSAR. Our evaluation of ECCS performance is described below.

ECCS Analyses

The applicant's submittal of a large break loss-of-coolant accident (LOCA) analysis was limited to a spectrum of three guillotine breaks, which was specific for the Diablo Canyon Nuclear Power Station. To supplement the analysis of the three breaks, the applicant referenced WCAP-8356, "Westinghouse ECCS Plant Sensitivity Studies," WCAP-8472, "The Westinghouse ECCS Evaluation Model-Supplementary Information," and WCAP-8565, "Westinghouse ECCS-Four Loop Plant 17x17 Sensitivity Studies," which demonstrated that the guillotine breaks are the worst cases for this plant type.

The analyses submitted identified the worst break size as the double-ended cold leg guillotine break with a Moody multiplier of 0.6. The calculated peak clad temperatures were 2030 degrees Fahrenheit for Unit 1 and 1931 degrees Fahrenheit for Unit 2, within the acceptable limit of 2200 degrees Fahrenheit (as specified in 10 CFR Part 50.46(b)). In addition, the maximum local metal/water reaction of 4.24 percent for Unit 1 and 2.9 percent for Unit 2 and a total core-wide metal/water reaction of less than 0.3 percent for both units were well below the allowable limits of 17 percent and 1 percent, respectively. The analyses for both units were performed based on an assumed total peaking factor of 2.32 at 102 percent of a rated power level of 3411 megawatts thermal, with a peak linear power density of 12.6 kilowatts per foot. This is the thermal rating for Unit 2, which is slightly higher than the rating for Unit 1.

The small break analysis which was submitted in Amendment 15 to the FSAR included a three break spectrum and referenced WCAP-8356. The small break analysis, which identified the 4-inch pipe break as the limiting small break with a peak clad temperature of 1520 degrees Fahrenheit, demonstrates that the small break LOCA is not limiting.

ECCS Containment Pressure Evaluation

The ECCS containment pressure calculations for Diablo Canyon were done using the Westinghouse ECCS evaluation model. We have reviewed the Westinghouse containment model and found it acceptable for ECCS evaluation. We required, however, that justification of the plant-dependent input parameters used in the analysis be submitted for our review on each plant. This information was submitted in Amendment 35 to the FSAR. The applicant has reevaluated the containment net free volume, the passive heat sinks, and operation of the containment heat removal system with regard to the conservatism for the ECCS analysis. This evaluation was based on measurement within the containment and from as-built drawings. Since, for the purposes of an ECCS analysis, it is conservative to overstate the heat removal capability and thereby calculate a low containment pressure, margins were added to the measured and as-built values. In addition, the containment heat removal systems were assumed to operate at their maximum capacities. Minimum operational values for the spray water and service water temperatures were assumed.

Based on our review we have concluded that since the ECCS evaluation model used complies with Appendix K to 10 CFR Part 50 and the plant dependent information used for the Diablo Canyon plants is reasonably conservative, the calculated containment pressures are in accordance with Appendix K to 10 CFR Part 50 of the Commission's regulations.

Single Failure Criterion

Appendix K to 10 CFR Part 50 of the Commission's regulations requires that the combination of ECCS subsystems to be assumed operative shall be those available after the most damaging single failure of ECCS equipment has occurred. The worst single failure, which was one that could minimize the emergency core cooling available to cool the core and yet provide maximum containment cooling, was identified by Westinghouse in their generic topical reports as the loss of a low pressure ECCS pump. In our evaluation of the Westinghouse topical reports, we concluded that the application of the single failure criterion was to be confirmed during the review of each plant. We have now completed our review of the Diablo Canyon ECCS with respect to single failures and determined that, subject to resolution of the matters discussed below, the results of the Westinghouse topical reports are applicable.

We have reviewed the piping and instrumentation diagrams for Diablo Canyon and determined that the inadvertent actuation of specific motor-operated valves could result in a loss of ECCS function which would be a worse single failure than the loss of a low pressure ECCS pump. As stated in Section 6.3.1 of the Safety Evaluation Report, we had previously identified certain locations where a single incorrectly positioned motor-operated valve could result in a loss of ECCS function. Further, in Section 6.3.1 of Supplement No. 2 to the Safety Evaluation Report, we stated that the applicant had committed to lock out electrical power to these valves and that this was an acceptable resolution of the matter. Since that time we have identified additional locations where a single spurious valve operation would result in a loss

of ECCS function. Two such valves, the containment sump isolation valves, were described in Section 6.3.1 of Supplement No. 3 to the Safety Evaluation Report.

We have now completed our review of the Diablo Canyon piping and instrument diagrams with regard to this matter. All of the valves involved and the modifications that will be required are described below. The following is a complete list of the motor operated valves identified by the applicant and staff which will require modification:

VALVE	Component Function	Failure Mode
8976	Isolates Refueling Water Storage Tank (RWST) from Safety Injection (SI) pumps	Loss of RWST flow to both SI pumps
8980	Isolates Regenerative Heat Removal (RHR) system from RWST	Loss of suction flow to both RHR pumps
8835	SI system shutoff valve	Inadvertent action of this valve would stop SI flow to all loops
8802 A&B	Isolates hot leg injection lines	Opening of either valve during emergency core cooling (ECC) injection and core reflood would allow injection into reactor coolant system (RCS) hot legs and cause steam binding
8703	Isolates the RHR system from the RCS hot leg	Inadvertent opening of this valve would permit injection into RCS hot leg and cause steam binding
8992	Isolates sodium hydroxide spray additive tank from containment spray pumps	Inadvertent closing of this valve would cause loss of sodium hydroxide flow to containment spray
8982 A&B	Containment recirculation pump supply to RHR pump	Loss of flow to RHR pumps

*8974 A&B	Shutoff SI pumps recirculation lines	Damage or malfunction of SI pumps during pumps' operation prior to alignment for recirculation
*8808 A,B, C,&D	Accumulator isolation valves	Inadvertent closing of these valves would stop accumulator flow
8809 A&B	RHR pump discharge to RCS cold leg loops	Reduction of ECC flow from RHR pumps to RCS

*Identified by the staff in the present review.

We have reviewed the consequences of the failures of the above valves and have evaluated the applicant's proposals for modification. We have concluded that the following modifications would be acceptable for complying with the single failure criterion:

(1) As has been proposed by the applicant, during power operation, power will be disconnected from valves 8976, 8980, 8835, 8802 A&B, 8809 B, 8703, and 8992 by racking out the circuit breaker at the motor control center. Valves 8976, 8980, 8835, 8809 B, and 8992 will be locked in the open position. Valves 8802 A&B and 8703 will be locked in the closed position.

(2) During power operation, power will be disconnected from valves 8808 A, B, C, & D by racking out the circuit breaker at the motor control center. These valves would be locked in the open position.

(3) During power operation, power will be removed from valves 8974 A&B and 8809 A. These valves will be in their open position and power will be restorable from the control room for switchover to the recirculation mode of operation.

(4) The applicant has the option of either removing power from 8982 A&B, with the valves in their closed position, while retaining the capability of restoring power from the control room, or, of installing two check valves in the RHR suction header, placing one between valves 8980 and 8700 A and the other between 8980 and 8700 B. Either modification is an acceptable means to eliminate the possible loss of flow to both RHR pumps in the event of the inadvertent actuation of either 8982 A or B.

We have determined that the modifications described above would be acceptable. Alternately, the applicant may propose and justify some other modifications. In either event we will require the modifications to be completed prior to plant operation and will include appropriate requirements in the technical specifications. In addition, we will review the detailed means of removing power from the valves and, where appropriate, the detailed means of restoring power from the control room to ensure that they conform to our position, which is documented in Branch Technical Position EICSB 18, "Application of the Single Failure Criterion to Manually-Controlled Electrically-Operated Valves" contained in Appendix 7A to our Standard Review Plan.

Long-Term Boric Acid Concentration Buildup

We have reviewed the proposed procedures and the system design for preventing excessive boric acid buildup in the reactor vessel during the long-term cooling period following a loss-of-coolant accident. Boric acid can concentrate in the reactor vessel during the initial cold leg injection phase due to boiling. This concentration is effectively terminated upon switching to simultaneous hot leg and cold leg injection about one day after a LOCA. We will require that the switchover time from cold leg to simultaneous hot and cold leg injection be changed from 24 hours, which the applicant proposed, to 19.5 hours after a loss-of-coolant accident. This shorter time will assure that, for cold leg breaks, the concentration of boric acid will not exceed 23.5 weight percent, which is 4 weight percent below the solubility limit at 212 degrees Fahrenheit. We have determined that the 4 weight percent margin is needed to account for uncertainties in predicting boric acid concentration in the reactor vessel. The applicant has committed informally to incorporate this provision in the plant's emergency procedures and, subject to documentation in the FSAR, we find this commitment acceptable.

We have reviewed the piping and instrumentation diagrams and found that the system proposed by the applicant for long-term cooling can be operated in a manner complying with the single failure criterion.

Submerged Valves

The applicant has submitted an analysis which shows that following a loss-of-coolant accident the maximum water level in the containment will be at the 96-foot 1-inch elevation. The applicant has identified four motor-operated valves which could be submerged under these conditions. Those motor-operated valves whose motor operators are located below the maximum water level are listed below:

Valve	Motor Bottom Elevation	Description
8808 A,B,C&D	94 feet - 11 inches	Accumulator tank isolation valves

These four accumulator tank isolation valves are required to be functional following a loss-of-coolant accident. These valves are normally open, but also receive a safety injection system opening signal in the event of a loss-of-coolant accident. Since the accumulator blowdown is completed within the first few minutes after a loss-of-coolant accident and well before the motor operators could become submerged, subsequent flooding will have no adverse effects.

Rod Bow

Recent generic information provided by Westinghouse indicates that the effect of rod-to-rod bowing on local power spike should be considered in evaluating the ECCS performance. Westinghouse has provided estimates of the 17x17 rod bow and has indicated that a maximum 5 percent spike penalty would be appropriately conservative. The Diablo Canyon Unit 1 and 2 ECCS performance evaluation was performed assuming a total peaking factor (F_Q) of 2.32 and the highest calculated peak clad temperature was 2030 degrees Fahrenheit for Unit 1. Extrapolation of the analysis to the limit of 2200 degrees Fahrenheit would result in an estimated limiting F_Q of 2.46. If the 5 percent rod bow power spike penalty were imposed, an adjusted limiting F_Q of 2.35 would result. Since this is greater than 2.32, we have concluded that the Diablo Canyon design has sufficient margin to account for the rod bow power spike penalty without requiring modification to the proposed technical specification limits on total peaking factor.

Conclusions

Based on our review as described above we have concluded, subject to satisfactory resolution of the matters concerning single failures of motor operated valves and documentation of the applicant's commitment regarding time of switchover to simultaneous hot leg and cold leg recirculation, that (1) the LOCA analyses that were performed are wholly in accordance with the requirements of Appendix K to 10 CFR 50, (2) the ECCS cooling performance conforms to the peak clad temperature and maximum oxidation and hydrogen generation criteria of 10 CFR 50.46, (3) ECCS cooling performance will be adequate despite any postulated failure of a single active component, (4) adequate systems are available to provide long-term core cooling to the reactor vessel and, therefore, (5) the emergency core cooling system design is acceptable.

We will report the resolution of the matters concerning single failures of motor-operated valves and documentation of the applicant's commitment concerning switchover time to simultaneous hot leg and cold leg injection in a supplement to the Safety Evaluation Report.

7.0 INSTRUMENTATION AND CONTROLS

7.2 Reactor Trip System

7.2.3 Process Analog System

In the Safety Evaluation Report we stated that we would require that the applicant either: (1) modify the present system to provide a minimum physical separation of six inches, or provide barriers between the control outputs of the isolation amplifiers and the protection system circuitry, including the input to the isolation amplifiers; or (2) qualify the present system, as implemented, by testing. The applicant submitted reports of tests in letters dated January 16, 1975, April 7, 1975 and November 24, 1975. The systems were tested for noise susceptibility including magnetic interference effects and maximum credible output cable voltage faults. The test results indicated that noise or interference from the non-safety portions of the system were not introduced into the safety portions and the equipment performed as designed before, during and after the tests. Therefore, based on our review, we have found the test program to indicate the acceptability of the system as installed at Diablo Canyon. Our evaluation was documented in a letter to the applicant dated April 22, 1976.

We consider this matter resolved.

7.2.5 Anticipated Transients Without Scram (ATWS)

In the Safety Evaluation Report we stated that we had not completed our evaluation of the information which had been submitted by the applicant concerning anticipated transients without scram. The current status of this matter is described below.

Our position with respect to anticipated transients without scram is provided in the technical report, "Anticipated Transients Without Scram for Water-Cooled Power Reactors," WASH-1270, dated September 1973. Unit 1 was classified by the staff as a "I.C." facility as defined in WASH-1270; for this Unit, WASH-1270 indicates an analysis describing and evaluating the consequences of a postulated anticipated transient without scram would be acceptable. Unit 2 was classified as a "I.B." facility; for this Unit, WASH-1270 indicates a program to incorporate any design changes necessary to assure that the consequences of anticipated transients without scram would be acceptable. The applicant submitted the information described by WASH-1270 in a letter dated October 1, 1974. In that letter the applicant referred to two Westinghouse topical reports, WCAP-8330, "Westinghouse ATWS Analysis," dated August 1974 and WCAP-7706, "An Evaluation of Solid State Logic Reactor Protection in Anticipated Transients," dated July 1971. The applicant stated that these reports contain the necessary analyses and that they are applicable to the Diablo Canyon Nuclear Power Plant. In addition, the applicant stated that Unit 1 as well as Unit 2 would be considered as a category "I.B." facility.

We evaluated these Westinghouse topical reports and presented our conclusions in a report, "Status Report on Anticipated Transients Without Scram for Westinghouse Reactors," dated December 9, 1975. This report describes a number of outstanding issues which must be resolved. We have discussed our status report with the Advisory Committee on Reactor Safeguards and we will consider the Committee's comments in developing our final position. We have requested that Westinghouse submit the information needed to resolve the outstanding issues related to the evaluation model by June 30, 1976. We plan to request that the applicant submit promptly thereafter (1) an analysis of the Diablo Canyon units using the approved Westinghouse evaluation model, (2) detailed descriptions of the design changes determined to be necessary from the analysis, and (3) a schedule for installing the design changes.

We will continue to review this matter and will require any changes indicated to be needed in the Diablo Canyon design by the result of approved analyses to be incorporated into the design in a timely manner.

9.0 AUXILIARY SYSTEMS

9.6 Other Auxiliary Systems

9.6.1 Fire Protection System

In the Safety Evaluation Report, we stated that the fire protection system was acceptable. Subsequent to the fire at the Browns Ferry facility (Docket Nos. 50-259, 50-260 and 50-296), we requested additional information from the applicant concerning fire stops in cable trays and at cable wall penetrations. In Section 22 of Supplement No. 3 to the Safety Evaluation Report, we stated that the applicant had not yet provided this additional information. The applicant provided this information in Amendment 36 to the FSAR.

We have reviewed this information and, based on our review, we have not changed our previous conclusion, as stated in the Safety Evaluation Report, that the fire protection systems meet the requirements of Criterion 3 of the General Design Criteria and, therefore, they are acceptable.

We consider this matter resolved.

We also note that further studies of fire protection systems for nuclear power plants are being conducted by the staff. When the results of these studies become available we will require, if the results so dictate, upgrading the fire protection systems at Diablo Canyon to further improve their capabilities for preventing unacceptable damage that could result from fires.

10.0 STEAM AND POWER CONVERSION SYSTEM

10.4 Other Features

In Supplement No. 3 to the Safety Evaluation Report we stated that we would report the results of our evaluation of the information which had been provided by the applicant concerning secondary system flow instability (feedwater hammer) in a future supplement to the Safety Evaluation Report. We have completed this evaluation as described below.

In a letter dated August 5, 1975 the applicant described two modifications being made to the Diablo Canyon design to reduce the possibility and/or consequences of feedwater hammer. These modifications are (1) minimizing the length of horizontal feedwater piping which could be emptied when the steam generator water level drops below the level of the feedwater ring, and (2) installation of inverted u-bend vents in each feedwater ring. In addition, in a letter dated March 16, 1976, the applicant informed us that the feedwater rings in the steam generators will be modified by the installation of J-tubes which are intended to prevent the feedwater ring from emptying when the steam generator water level drops below the level of the feedwater ring. The applicant also stated that tests conducted at the Trojan Nuclear Plant (Docket No. 50-344) with steam generators of the same design and with the same modifications and a similar feedwater system showed that flow instability would not occur at Diablo Canyon. On this basis, the applicant did not propose a similar test at Diablo Canyon. The applicant also stated in the letter of August 5, 1975, based on experience at other plants, that limiting the feedwater flow rate could eliminate the possibility of feedwater hammer, even in the absence of the modifications described above.

We are presently evaluating feedwater hammer on a generic basis for all pressurized water reactors. While we believe that the applicant's modifications may preclude unacceptable damage from feedwater hammer, pending completion of our studies we will require that the applicant perform tests to demonstrate that uncovering the modified feedwater sparger and subsequent refill via the auxiliary feedwater system over the complete range of allowable refill rates will not result in damage from feedwater hammer. Until these tests have been performed to establish a particular limit for this plant, the steam generator water level recovery rate will be limited to 1.2 inches per minute or less. This recovery rate was demonstrated to be acceptable in tests performed at the Calvert Cliffs Nuclear Power Plant Unit No. 1 (Docket No. 50-317). Based on experience at Calvert Cliffs and other facilities, we have determined that this limiting refill rate is conservative for the Diablo Canyon facility.

We will include the appropriate limitations in the technical specifications.

We consider this matter resolved.

11.0 RADIOACTIVE WASTE MANAGEMENT

Our evaluation of the radioactive waste management systems was presented in the Safety Evaluation Report where we found these systems to be acceptable.

Since then the Commission has adopted Appendix I to 10 CFR Part 50 (effective June 4, 1975 and amended September 4, 1975) entitled "Numerical Guides for Design Objectives on Limiting Conditions for Operation to Meet the Criterion 'As Low As Is Reasonably Achievable' for Radioactive Material in Light Water Cooled Nuclear Power Reactor Effluents." Appendix I to 10 CFR Part 50 requires that, for plants with construction permits issued before January 2, 1971, the applicant submit, by June 4, 1976, the information necessary to evaluate the means for keeping radioactivity levels in effluents as low as is reasonably achievable. Diablo Canyon falls in this category.

We provided guidance to the applicant concerning submission of this information in a letter dated February 25, 1976. Further, staff representatives met with the applicant on April 1, 1976 to provide additional guidance. When the information is submitted, we will review it and report the results of our evaluation in a supplement to the Safety Evaluation Report.

22.0 CONCLUSIONS

In Section 22 of Supplement No. 3 to the Safety Evaluation Report, we stated that several items were still outstanding, and that favorable resolution of these items would be required before operating licenses for Diablo Canyon Units 1 and 2 could be issued. Resolutions for a number of those items have been presented in this supplement. Items which remain outstanding are summarized below.

1. An evaluation of the plant's capability to withstand an earthquake of magnitude 7.5 on the Hosgri fault (Section 3.7 of this supplement) including a tsunami generated by such an earthquake (Sections 2.4.2, 2.4.3 and 2.4.5 of Supplement No. 1.

2. An evaluation of the environmental and seismic qualification of Category I electrical, instrumentation and control equipment (Sections 3.10 and 7.8 of the Safety Evaluation Report).

3. An evaluation of the means to be used to ensure that single failures in motor operated valves cannot result in a loss of emergency core cooling system function and documentation of the applicant's commitment regarding the switchover time to simultaneous hot leg and cold leg injection following a loss-of-coolant accident (Section 6.3 of this supplement).

4. An evaluation of the consequences of Anticipated Transients Without Scram (Section 7.2.5 of this supplement).

5. An evaluation of the ability of the liquid and gaseous radioactive waste management systems' ability to meet Appendix I to 10 CFR Part 50 (Section 11.0 of this supplement).

6. An evaluation of the effects of postulated pipe breaks outside containment (Section 3.6 of the Safety Evaluation Report).

7. An evaluation of the plant's tornado missile protection (Section 3.5 of Supplement No. 3 to the Safety Evaluation Report).

Subject to favorable resolution of the outstanding matters described above, the conclusions as stated in Section 22 of the Safety Evaluation Report remain unchanged.

APPENDIX A

CONTINUATION OF THE CHRONOLOGY OF THE RADIOLOGICAL REVIEW

September 17, 1975	Letter from applicant regarding schedule for providing information requested September 4, 1976.
September 26, 1975	Letter to applicant regarding outstanding issues and requesting schedule for submitting additional information.
October 6, 1975	Letter from applicant providing schedule requested September 26, 1975.
October 6, 1975	Submittal of Amendment 35 including (1) partial response to questions dated February 12, 1975, and (2) miscellaneous changes.
October 17, 1975	Letter from applicant indicating that ECCS information was submitted in Amendment 35.
October 21, 1975	Letter from applicant providing additional information on protection against tornado-generated missiles requested July 11, 1976.
October 21, 1975	Submittal of Amendment 36 including (1) partial responses to requests for information dated July 11, 1975, August 7, 1975 and September 26, 1975, and (2) miscellaneous changes.
October 30, 1975	Submittal of Amendment 37 incorporating (1) completion of responses to request for information dated February 12, 1975, and (2) reorganization of Section 15.4 of FSAR.
November 11, 1975	Letter from applicant submitting reports entitled (1) "Teleseismic Location of the 1927 Lompoc Earthquake," and (2) "Aftershocks of the 1927 Lompoc Earthquake."
November 12, 1975	Letter from applicant submitting report entitled, "Western Geophysical Company and Shell Oil Company Proprietary Seismic Reflection Data from the Offshore Region between Point Estero and Point Arguello: Basic Data, Interpretive Data, and Discussion," and requesting that the report be withheld from public disclosure as proprietary data.
November 14, 1975	Letter to applicant providing revised review schedule and requesting additional information on geology, seismology and seismic design.

November 24, 1975	Letter from applicant providing supplement to report entitled, "Westinghouse Protection Systems Noise Tests."
November 25, 1975	Meeting with applicant to discuss responses to request for information dated November 14, 1975.
December 1, 1975	Letter from applicant submitting additional copies of reports previously submitted November 11, 1975.
December 4, 1975	Meeting with applicant to discuss technical specifications.
December 8, 1975	Letter from applicant submitting additional copies of proprietary data submitted November 12, 1975.
December 8, 1975	Letter from applicant submitting geophysical survey records in partial response to request for information dated November 14, 1975.
December 10, 1975	Letter to applicant informing him of safety question regarding reactor pressure vessel support system and requesting information.
December 11, 1975	Letter from applicant submitting report entitled, "Seismic Reflection Data from the Offshore Region Between Point Estero and Point Arguello: Interpretive Data and Discussion," which constitutes a non-proprietary version of the material submitted November 12, 1975.
December 16, 1975	Letter from applicant submitting USGS offshore geophysical survey records in partial response to request for information dated November 14, 1975.
December 22, 1975	Submittal of Amendment 38 including (1) information on electrical, instrumentation and control systems (equipment qualification) in partial response to request for information dated August 7, 1975, and (2) miscellaneous changes.
December 24, 1975	Letter from USGS to NRC staff providing draft report on Diablo Canyon.
December 30, 1975	Letter from applicant submitting location data for electrical equipment related to pipe breaks outside containment in partial response to request for information dated August 7, 1975.
January 8, 1976	Letter from applicant transmitting reports on reactor containment building integrated leak rate test and structural integrity tests.
January 12, 1976	Letter from USGS to NRC staff providing draft report on Diablo Canyon.

January 13, 1976	Letter from applicant regarding design of reactor pressure vessel support system in response to request for information dated December 10, 1975.
January 14, 1976	Meeting with applicant to discuss geology and seismology.
January 14, 1976	Letter from applicant providing information on pipe breaks outside containment in partial response to request for information dated August 7, 1975.
January 19, 1976	Letter from applicant submitting a report entitled, "A Discussion of the Application of the Migration Process to Western Geophysical Company Seismic Reflection Line W74-12 in the Vicinity of the Hosgri Fault Zone, in the Area Offshore from the Diablo Canyon Power Plant Site," in partial response to a request for information dated November 14, 1976 and requesting that the report be withheld from public disclosure as proprietary data.
February 2, 1976	Submittal of Amendment 39 including miscellaneous changes and Amendment 40 including partial response to request for information dated November 14, 1976.
February 5, 1976	Meeting with applicant and USGS to discuss geology and seismology.
February 24, 1976	Letter to applicant transmitting draft Regulatory Guides 1.AA through 1.FF related to radioactive waste management calculations required by Appendix I to 10 CFR 50.
February 25, 1976	Letter to applicant providing guidance on submitting required radioactive waste management information per Appendix I to 10 CFR 50, and requesting the applicant's plans for compliance with Appendix I.
February 25, 1976	Latest completion dates in Construction Permits for Units 1 and 2 were extended by the Commission.
March 2, 1976	Letter from applicant submitting a report entitled, "A Discussion of the Application of the Migration Process to Western Geophysical Company Seismic Reflection Line W74-12 in the Vicinity of the Hosgri Fault Zone, in the Area Offshore from the Diablo Canyon Power Plant Site," which constitutes a non-proprietary version of the information submitted January 19, 1976.
March 2, 1976	Submittal of Amendment 41 including miscellaneous changes.
March 2, 1976	Letter from applicant submitting additional copies of material submitted November 12, 1975 and January 19, 1976.

March 16, 1976	Letter from applicant providing update of information on secondary system flow instability that was submitted August 5, 1975.
March 23, 1976	Letter from applicant submitting errata for containment structural integrity test report submitted January 8, 1976.
March 30, 1976	Letter from applicant stating that plans for compliance with Appendix I to 10 CFR 50 would be submitted after a meeting of April 1, 1976 with the staff.
April 1, 1976	Meeting with the applicant (and other applicants) to provide further guidance on compliance with Appendix I to 10 CFR 50.
April 21, 1976	Letter to applicant stating that information submitted November 12, 1975, December 8, 1975 and January 19, 1976 would be withheld from public disclosure pursuant to 10 CFR 2.790.
April 20, 1976	Meeting with applicant to discuss seismic design.
April 22, 1976	Letter to applicant providing staff evaluation of report entitled, "Westinghouse Protection System Noise Tests," submitted January 16, 1975 and revised April 7, 1975 and November 24, 1975.
April 29, 1976	Letter from USGS to NRC staff providing report on Diablo Canyon.

APPENDIX B

BIBLIOGRAPHY

(Documents referenced in or used to prepare Supplement No. 4 to the Safety Evaluation Report for the Diablo Canyon Nuclear Power Station, Units 1 and 2, are listed below. This list of documents is in addition to those previously listed in the bibliographies for the Safety Evaluation Report and Supplement No. 1 to the Safety Evaluation Report.)

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Geology, Seismology, and Foundation Engineering

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7. Bonilla, M. G. in R. L. Wiegel (ed.), 1970, "Earthquake Engineering," Prentice Hall, 518 pgs.

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United States Department of the Interior

GEOLOGICAL SURVEY
RESTON, VIRGINIA 22092

APR 29 1976

RECEIVED
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U.S. NUCLEAR REGULATORY COMMISSION
Mail Section

Mr. Benard C. Rusche
Director of the Office of Nuclear
Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Rusche:

Transmitted herewith, in response to your request, is a review of the geologic and seismologic data relevant to the Diablo Canyon Nuclear Power Station, Units 1 and 2 (NRC Docket Nos. 50-275 OL and 50-323 OL).

This review was prepared by F. A. McKeown and J. F. Devine of the U.S. Geological Survey. Mr. McKeown was assisted by Holly Wagner, David McCulloch and Robert Yerkes in the preparation of portions of this review. Mr. Devine was assisted by Robert Page and Wayne Thatcher in the preparation of portions of this review.

We have no objection to your making this review part of the public record.

Sincerely yours,

Henry W. Coulter
Acting Director

Enclosure

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

4308

PACIFIC GAS AND ELECTRIC COMPANY
DIABLO CANYON SITE, UNITS 1 AND 2
SAN LUIS OBISPO COUNTY, CALIFORNIA
AEC DOCKET NOS. 50-275 AND 50-323

Geology and Seismology

This is a review of the geological and seismological information contained in Amendments 31, 32, 34, 37 and 40 of the Final Safety Analysis Report (FSAR) for the Diablo Canyon nuclear power plant site. The review also includes a discussion of questions concerning the size of an earthquake to be expected on offshore fault zones raised by some California scientists since review of the amendments.

The amendments were prepared by the Pacific Gas and Electric Company (PG&E) in response to a request in a letter dated February 12, 1975, from the Nuclear Regulatory Commission (NRC) for certain additional information relevant to design basis earthquake issues, which have been the principal problems requiring additional earth sciences information and analyses. To support assertions in the FSAR through Amendments 11, 19, and 20, five requests for information (referred to as questions in the Amendments) were made.

2.17. Provide additional discussion and arguments for determining the maximum earthquake that can be expected on faults of various ranks within the San Andreas system. Relate the discussion to historic seismicity.

2.18. Provide additional documentation, including seismic reflection profiles, on the intersection of the Hosgri fault zone with the Transverse Range faults. Include geologic maps southward of those provided in the FSAR showing the structural relationships of the Transverse faults and structures having a northwest trend.

2.19. Provide additional documentation, including seismic profiles, on the northern reaches of the Hosgri fault zone. Include a fuller development of your views on the structural relationship of the Hosgri fault to the San Simeon fault.

2.20. Provide additional information on the location of the 1927 event, together with its probable mechanism. Discuss probable relationships of this event to the geologic structure in the region.

2.21. Provide your evaluation of the maximum credible earthquake on the Hosgri fault zone. Assuming this event occurs along the segment of the Hosgri fault zone nearest the site, evaluate its response spectrum at the site and compare it with the design response spectrum.

The response in the FSAR to the questions has provided considerable additional geologic and seismologic information and analyses. Many uncertainties in the data and interpretations still exist. Among the most important of these are: (1) the location and mechanism of the 1927 earthquake, (2) the exact relation of the Hosgri fault zone to faults in the Transverse Range system and the San Simeon fault, (3) the continuity of some faults, (4) the relative amounts of dip-slip and strike-slip movement on the Hosgri fault zone, (5) the sense of displacement on parts of the Hosgri zone, (6) identification and correlation of acoustical units, and (7) kinematic relations among different fault zones.

In addition to these uncertainties, some information shown on the profiles is not shown on the maps and vice versa, and some profile data are not included that are important to evaluate the extension or character of some faults. Because geologic maps developed from seismic reflection profiles are based upon much interpretation that may differ among several interpreters, it was necessary for the purposes of our

review to make independent interpretations of the seismic profiles. These independent interpretations are somewhat different than the interpretations presented in Amendments 31 and 32. The major differences are briefly described in appropriate sections of this review.

Although some changes in, and additions to, geologic and seismologic details have been made in Amendments 31, 32, 34, 37 and 40 compared with previous data in the FSAR, no major changes can be made in our conclusions that were stated in the review of the FSAR, and Amendments 11, 19, and 20, which was transmitted to the NRC from the Director of the United States Geological Survey by letter of January 28, 1975. The pertinent statement in our previous conclusions was as follows: "Earthquakes along the EBZ[1] presumably would not be as large as expected on the San Andreas fault, however, from the information presently at hand we can find no evidence that would preclude the occurrence of an earthquake as large as events characteristic of subparallel strike-slip faults, which bound basins, such as the Santa Maria, in the San Andreas system and which do not transect structural provinces." The size of an earthquake on faults that bound basins was not specified in this conclusion. For reasons stated in subsequent parts of this review, however, the magnitude of the design basis earthquake for the Diablo Canyon nuclear reactor site should be about 7.5 and located on the Hosgri fault zone. This is based principally on the fact that the November 4, 1927, earthquake had a magnitude of

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[1]As defined in the FSAR, EBZ refers to the East Boundary fault zone, which is the Hosgri fault zone.

7.3 and that the best estimates of its location indicate that it could have occurred on the Hosgri fault. Furthermore, the range in magnitude is compatible with the largest recorded or estimated magnitudes of earthquakes that have occurred on subsidiary faults in the San Andreas system.

Selected comments important to an evaluation of the amendments are outlined below.

Amendment 31

NRC Question 2.18

On figures 8 and 9 relative displacement on the Hosgri fault between Point Buchon and Point Sal is shown to be down on the east. On figure 10 relative displacement on the southern extension of the Hosgri fault south of Point Sal is down on the west, which is compatible with the argument that the Hosgri fault is the east boundary of a portion of the Santa Maria Basin. Changes in direction of relative movement, however, are very suggestive of lateral displacement, which may have occurred after development of the basin and bounding faults.

On page 9, reference is made to figure 11 as evidence that no scarp-forming seismic events have occurred on the southernmost part of the Hosgri fault since prior to the Wisconsinan stage of the Pleistocene. It is true that no offset of the ocean floor is evident on figure 11. However, close inspection of figure 11 shows offset of the post-Wisconsinan unconformity when sighting along it or placing a straightedge along the mapped trace. Also, faulting of the post-Wisconsinan sediments cannot be precluded because a change in acoustical

signature is evident across an upward projection of the fault shown in figure 11. The change in the acoustical signature of unit A2 across the fault is quite clear and may be evidence of lateral movement on the fault.

It is not clear from the profiles in figures 13a and 13b that the disturbed zones in them that are inferred to represent the West Hosgri fault are the same. At least three additional faults can be interpreted in the profile of figure 13b. Also a disturbed zone appears to be between stations 133 and 136 in the profile of line 13a. Kelez, Bartlett, and Polaris survey lines crisscross this area and evidence from them to support or negate the suggested correlation of disturbed zones is not apparent.

An independent interpretation of the seismic profiles in the offshore area from about Point Sal to about five miles south of Point Arguello indicates that the Hosgri fault extends at least five miles south of Point Arguello and does not turn eastward as suggested in Amendment 31.

Although the Lompoc fault zone appears to have offset the sea floor, and may, therefore, be considered capable of movement again, its length of only about eight miles as inferred by the applicant appears to be incompatible with a magnitude 7.3 earthquake. An independent interpretation of the seismic profiles in the area of the Lompoc fault differs from that of the applicant in that it shows that the Lompoc fault zone is about 20 miles long; the longest single fault in the zone is about 15 miles in length. Furthermore, the displacement

is interpreted to be dip slip or possibly oblique slip; rather than reverse slip as suggested by the applicant.

NRC Question 2.19

As noted in the previous section, the sense of displacement on the southern part of the Hosgri fault is up on the west side, figure 1 (N), and therefore is not compatible with its being primarily related to basin development. However, an alternative interpretation suggests the displacement on the Hosgri fault in figure 1 to be down on the west.

Figure 1 (N) has three buried faults not shown on Plate I. This leads to questions concerning the interpretation of some of the data in the report.

Another instance of faults shown in profile but not on a map is seen from comparison of figure 4 (N) and Plate I. The correlation of faults between Lines 16 and 12 (figures 3 (N) and 4 (N)) is questionable. A profile along Line 14 would help. Also, an interpretation of Line 10 should be included.

Although the straight coast line between Cambria and Point Estero suggests that the extension of the San Simeon fault is just offshore; data are lacking to prove this. None of the data presented in Amendment 31 preclude the San Simeon fault from intersecting the Hosgri fault offshore between Cambria and Point Estero. The two faults even as shown on Plate II (N) are less than 2.5 miles apart and could very well be tectonically coupled to each other by an en echelon or anastomosing series of faults which is characteristic of faults in the coast ranges. Such coupling of the Hosgri and San Simeon faults is supported by

interpretation of stratigraphic sections recently reported by Hall (1975). He infers that "...the San Simeon and Hosgri faults are part of the same system,..." and that 80 km or more of right slip has occurred along the system during the last 5 to 13 million years.

Figures 7a (N) and 7b (N) are very puzzling. They show an inflection in the sea floor over the Hosgri fault and a drastic change in the thickness and acoustical signature of unit A2, assuming A2' is correlative with A2. In addition to vertical displacement, lateral displacement, which is not mentioned, could be interpreted from these profiles. However, the basis for separating A2' from A3 is not apparent. Similarly, it is not apparent why unit A', east of the fault, is terminated. It appears to continue to the east edge of these profiles.

On figure 11a (N) the A2 unit east of the fault at station 119 is correlated with the Monterey formation (p. 8, NRC Question 2.19, Amendment 31), but the signature of the A2 unit west of this fault is completely different. This inferred lithologic change, as elsewhere, suggests lateral displacement.

NRC Question 2.20

On page 10 it is reasoned that both the Hosgri and West Hosgri faults can be eliminated as sources of the 1927 earthquake because neither the sea floor nor the post-Wisconsinan unconformity are offset in the epicentral area of the earthquake. This reasoning is not satisfactory because typically surface rupturing of a fault is discontinuous, and offset may not be detected if the displacement had a

large lateral component. Furthermore, as stated on page 4 of this review, the base of post-Wisconsinan sediments is offset, and a fault in the sediments cannot be precluded in figure 11. The evidence, therefore, to eliminate the Hosgri fault as the source of the 1927 earthquake is inadequate. As previously stated, the length of the Lompoc fault appears to be incompatible with the magnitude of the 1927 earthquake.

Figure 1 shows that segments of the Hosgri fault zone, the Lompoc fault, Purisima fault, and Lion's Head fault occur within the error circle of Gawthrop and error ellipse of Engdahl for the 1927 earthquake. However, all of the faults are outside of the area designated by Smith as the "inferred distribution of aftershock sequence of the 1927 earthquake." The 1927 earthquake, therefore, cannot be unequivocally located on any one of these faults. The Hosgri fault, however, is closer to the center of the estimate of error than the other faults and, therefore, must be considered as a possible fault on which to locate the earthquake.

Amendment 32

NRC Question 2.17

Although this section contains descriptions and explanations of the "kinematics of structural behavior in the south-central California region..." contemporary seismic activity is not fully explained. Also, we do not agree with some statements given as fact. For example, on page 2 it is stated as fact that the 1927 M.7.3 earthquake occurred on the Lompoc fault. This is not fact but a highly controversial

assumption. Item 2 on page 2 of this amendment indicates that the Lompoc and San Andreas are the only faults in the southern Coast Ranges that "reflect substantial late Quaternary surface deformation." As defined on page 3 of this amendment, "substantial" clearly includes the San Simeon fault, which as stated on page 7 of this review may be coupled with the Hosgri fault. The attempt to explain the large magnitude by using the logic that the Lompoc fault is in a transition zone between the Coast Ranges and Western Transverse Ranges applies to other faults in the zone including the southern part of the Hosgri fault.

Amendment 34

NRC Question 2.21

The maximum credible earthquake of 6 1/4 - 6 1/2 on the Hosgri fault zone used in this section to derive peak site ground acceleration is unacceptable because as stated previously the 1927 earthquake with a magnitude of 7.3 cannot be precluded from having occurred on the Hosgri fault. Although we believe that the 1927 earthquake should be used to estimate the safe shutdown earthquake, fault length-magnitude relationships have also been considered. The uncertainties in these relationships and the assumptions involved in the use of them are well known. Nevertheless, we may consider that the Hosgri fault is about 90 miles (144 km) long, or even greater if it is coextensive with the San Simeon fault. The part of this total length that may rupture during an earthquake is highly conjectural, particularly in view of the complex tectonic style of the faults in question. However, using a reasonable

factor for continuous rupture along a discontinuous zone of deformation, in our judgment, it is prudent to consider magnitude 7 as a possible minimum magnitude based on this criterion above, exclusive of the consideration of the 1927 earthquake.

Recently some earth scientists in California have discussed the possibility that the Hosgri fault zone not only may intersect or be coextensive with the San Simeon fault, but that the San Simeon fault may connect with the San Gregorio fault, presumably in the vicinity of Monterey Bay. It is argued that these three faults could comprise a system that may make it capable of generating a magnitude 8 earthquake. Available data, although incomplete, do not substantiate this inferred system of faults in the sense that it is a long linear fault along which major movements are occurring and, therefore, is capable of a magnitude 8 or larger earthquake.

It is well known that earthquakes with instrumentally measured magnitudes of 8+ generally occur along major discontinuities that may be either subduction zones or transform faults. In western North America the only such discontinuity recognized is the San Andreas fault. Not only is there no record of a magnitude 8 earthquake on the offshore system, but significant differences in tectonic style exist between that system and the San Andreas fault, which strongly suggest that the great length of rupturing associated with magnitude 8 earthquakes on strike-slip faults would not occur. These differences are outlined below:

(1) As stated previously, an interpretation that the San Simeon intersects the Hosgri fault zone offshore between Cambria and Point Estero cannot be precluded. Such an intersection would permit a nearly straight line continuation of the Hosgri zone. However, interpretations by Hoskins and Griffiths, the applicant, and Wagner all show continuation of the Hosgri zone or branches of it north of any postulated intersection. If the San Simeon fault does not intersect the Hosgri zone, then they are en echelon to each other as originally interpreted by Hoskins and Griffiths. The tectonic style of this area, therefore, is one of branching or en echelon faults.

(2) Data on the relationship of the San Simeon fault to the San Gregorio fault have not been provided by the applicant nor were they requested. The Hosgri fault zone is comprised of many discontinuous, anastomosing, and en echelon faults as interpreted by both Wagner and McCulloch, and the applicant. Relationships between HSS zones appear to be similar to the style of faulting in the coast ranges: an anastomosing, en echelon pattern unlike that of the San Andreas fault

Offshore faults north of Point Piedro Blancas do not form a single continuous fault. Greene and others (1973) show the San Gregorio fault connecting with the onshore Palo Colorado fault northeast of the Sur-Nacimiento fault zone. Furthermore, the San Simeon fault if projected northwest immediately offshore is truncated by the Sur-Nacimiento zone (Crowell, 1975). These relationships appear to preclude any similarity to the continuous style of the San Andreas fault.

(3) The Hosgri zone and the San Simeon fault are considered in this review as part of the San Andreas system of faults. This interpretation is made because (a) of evidence of lateral movement along the Hosgri fault zone and the San Simeon fault, (b) these faults like coast range faults are subparallel to the San Andreas fault, and (c) the regional stress field responsible for the plate boundary movements concentrated along the San Andreas fault may reasonably be expected to cause lateral movement on subparallel faults. Much geologic and seismologic evidence, however, shows that the major plate boundary movements are occurring on the San Andreas fault. Speculation that the major movements now occurring on the San Andreas fault should transfer tens of miles to another part of the system, which is discontinuous and nonlinear, within a few decades or perhaps several hundred years cannot be supported with available geologic evidence.

(4) The Hosgri fault zone and San Simeon fault are recognized as the eastern boundaries of offshore basins with large vertical displacements. The evidence for this is compelling, and the presence of the basins is reason for exploration by oil companies. In our review we have not disputed this evidence, but argued that the displacement on these basin-bounding faults in the current stress regime may have a large component of lateral displacement should an earthquake occur on them. These faults apparently do not form crustal plate boundaries which suggest that both their length and depth are not of the order of plate boundary faults and probably would not support earthquakes as large as those that occur along crustal plate boundary faults.

The suggestion that the Hosgri-San Simeon-San Gregorio faults comprise a system capable of a magnitude 8 earthquake is a legitimate and serious question, which has been considered since discovery of the Hosgri fault zone by Hoskins and Griffiths (1971). It is our current judgment, however, based upon the data in the FSAR, data in the literature, some work in progress within the USGS, present concepts of earthquake source areas along the west coast of the U.S., and the arguments given above that such faults have not been demonstrated to be capable of generating magnitude 8+ earthquakes.

In essence the Hosgri, San Simeon, and San Gregorio faults, even if parts of a common zone of deformation, have the dominant characteristics of subsidiary faults within the San Andreas system. Such subsidiary faults have no record of or estimate of earthquakes larger than magnitude 7.5 on them.

Conclusions

Although the FSAR includes a considerable amount of new information and analysis, the only change that can be made in the original conclusions transmitted to the NRC on January 28, 1975, is to be more specific in our estimate of the design basis earthquake. This is based upon the following facts and judgments.

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 our review of January 28, 1975, but such changes are even more abundant in the profiles of Amendment 31. 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 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 related to vertical displacement on the Hosgri fault in the epicentral area of the 1927 earthquakes does not eliminate it as a source. Surface rupture is generally discontinuous, and if lateral slip occurred, it probably would not be detected. Offset of the base of post-Wisconsinan sediments and probable faulting of them is evidence of post-Pleistocene movement.

For the above reasons and discussions given in the review, we conclude that the 1927 earthquake could have occurred on the Hosgri fault and that a similar earthquake with a magnitude of about 7.5 could occur in the future anywhere along the Hosgri fault.

6. We recognize the suggestion that the Hosgri, San Simeon, and San Gregorio faults may comprise a system capable of magnitude 8 earthquakes. It is our judgment, however, that these faults are subsidiary faults within the San Andreas system and such faults have not been demonstrated to be capable of magnitude 8+ earthquakes.

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.

It is intended, also, that this potential earthquake be considered in addition to all earthquakes considered previously by the applicant during the construction permit review process.

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