UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION RELATED TO

DIABLO CANYON NUCLEAR POWER PLANT, UNIT NO. 2

PIPEWAY STRUCTURE

1.0 INTRODUCTION

The staff presented its safety evaluation of the seismic design of the Unit 2 pipeway structure in Section 8 of SSER 29 (March 1985). Several open items remained after SSER 29. These included the Hosgri analysis of the Unit 1 pipeway structure and the evaluation of stresses in both units for design earthquake (DE) and double design earthquake (DDE) events.

The Unit 1 Hosgri analysis for the pipeway structures was performed by Westinghouse. This analysis was reviewed by the staff and accepted with open items listed in Section 4 of SSER 32 (July 1985). All of the open items of SSER 29 were resolved in SSER 32 except for some concerns regarding the acceptability of the methodology used by PG&E to perform the DE and DDE load combinations. PG&E obtained the DE and DDE load combinations by applying a factor to the Hosgri load case results. The factor was taken as the peak spectral DE or DDE value at the primary mode frequency of the pipeway structure to the Hosgri spectral value. The following recommendations was made in SSER 32:

"Prior to start-up following the first refueling outage PG&E shall complete a confirmatory analysis for the pipeway structure to further demonstrate the adequacy of the pipeway structure for load combinations that include the design earthquake (DE) and double design earthquake (DDE)."

By letter of April 10, 1986 (DCL-86-095), PG&E submitted its final report on the pipeway structure, "Confirmatory Analysis of the Unit 2 Pipeway Structure for the DE and DDE." BNL performed a review of this report and it was determined that an audit of the models, analyses and calculations was needed to complete the review. An audit was conducted at PG&E's offices in San Francisco on March 4-5, 1987.

2.0 STAFF EVALUATION

BNL reviewed the report entitled "Confirmatory Analysis of the Unit 2 Pipeway Structure for DE and DDE" submitted by PG&E. According to this report a complete time history analysis was performed by PG&E for the pipeway structure due to the DE and DDE seismic loadings. An audit of the models, analyses and calculations was required to complete the review. NRC staff and Dr. A. J. Philippacopoulos, consultant from Brookhaven National Laboratory (BNL), audited the PG&E models, analyses and calculations for the Diablo Canyon Unit 2 pipeway structure at the PG&E offices. The audit included the review of the following information:

(a) Seismic model of pipeway structure for DE and DDE calculations,

(b) Response calculations including computer printouts for both horizontal and vertical seismic inputs,

(c) Details of composite damping calculations,

(d) Calculations of stress ratios for load combinations considered,

(e) Detailed comparisons between new stress ratios (confirmatory analysis) and previous ones (approximate analysis), and

(f) Extrapolation of Unit 2 pipeway analysis results to Unit 1 pipeway structure.

The findings of the audit conducted by the staff and BNL consultant follow.

The seismic analysis of the pipeway structure performed by PG&E prior to the issuance of SSER 32 (July 1985) was based on an equivalent static method. Using that approach, stress ratios were derived for critical members of the pipeway structure using spectral ratios of the DE/DDE to the Hosgri spectra. The confirmatory seismic analysis of the pipeway structure, submitted by letter of April 10, 1986 (DCL-86 095), was based on rigorous time history analysis of the pipeway structure using the acceleration time histories. This audit focused on the rigorous time history analysis of the pipeway structure and in particular on:

(a) seismic model,
(b) response calculations,
(c) composite damping calculations,
(d) evaluation of stress ratios,
(e) comparison between the confirmatory and the approximate analysis results, and
(f) applicability of Unit 2 results to Unit 1.

The time history analysis performed by PG&E demonstrates that the load combinations using DE/DDE loading lead to stresses that are within the allowable limits. The modeling was found to be acceptable except for the following three concerns which were raised during the audit:

(a) The same model is used for the DE/DDE analyses as was used for the Hosgri analyses. The Hosgri criteria allowed the PG&E to neglect the SSI effects. A concern was raised as to whether it was valid to neglect SSI effects for the DE/DDE load cases.

(b) The dead load case was somewhat different for the confirmatory case than for the Hosgri case. The basis for the different treatment and the resulting difference in dead load stresses were identified as a concern requiring disposition.

(c) The confirmatory analysis used 2% of critical damping for the structure and 0.5% of critical damping for the piping. It was shown in the FSAR that the response spectra derived from the DDE time history adequately envelops the 5% design spectra. A concern was raised as to whether the response spectra for the DDE time history envelopes the spectra with lower damping values.

PG&E provided a response to these concerns on March 16, 1987 (see Enclosure 2 to the audit report dated March 23, 1987):

(a) PG&E gave three reasons as to why the exclusion of SSI effects should be acceptable:

(1) SSI effects have been shown to reduce the fundamental frequency of the containment from 4.5 cps to 4.0 cps. This small change in frequency would not be expected to result in significant changes in seismic induced stresses.

(2) Seed and Lysmer performed parametric studies in 1978 (Seed and Lysmer, "Analysis of Soil-Structure Interaction Effect During Earthquakes for the Diablo Canyon Nuclear Power Station," July 7, 1978) and concluded that SSI effects were not important except for some small amount of rocking induced in the containment. Since the pipeway structure is attached to the lower part of the structure, the rocking effects are not significant.

(3) NRC previously accepted the model neglecting SSI for the Hosgri analysis.

The first two reasons cited above for neglecting the SSI effects provide sufficient basis for the staff to accept the DE/DDE models as used in the confirmatory analysis.

(b) With respect to the item (b) staff concern, PG&E indicated that the dead load model used for the confirmatory analysis was selected to be different from that used for the original analysis so that the dead load model could be the same as that used for the time history analysis. The differences involved were: a better treatment of support loads from large bore piping and a condensation of some of the small structural members supporting platforms. The licensee showed that load combinations using the original dead load model result in higher total stresses than with the new dead load model. The combined stresses are, however, still acceptable.

(c) With respect to concern item (c) PG&E's response indicated that according to the updated FSAR, the allowable damping values for DDE seismic evaluations are: 1/2% for piping, 2% for steel and 5% for concrete. In the confirmatory analysis, however, PG&E used 2% damping for both the steel and the concrete elements in the dynamic model. This assumption leads to conservative results since the

concrete is allowed for up to 5% damping. Therefore, the damping values used by PG&E in the confirmatory dynamic analysis of the pipeway structure satisfy the FSAR requirements and are acceptable to the staff.

3.0 CONCLUSION

In response to the staff's concerns regarding the adequacy of the pipeway structure of the Diablo Canyon Nuclear Plant documented in SSER 32, PG&E performed a confirmatory study entitled "Confirmatory Dynamic Analysis of the Unit 2 Pipeway Structure for DE and DDE." Based on the analysis, PG&E concluded that the original seismic analysis for the DE and DDE events was conservative. The staff consultant reviewed PG&E's confirmatory report and performed an audit of the pertinent calculations. The consultant and the staff conclude that the PG&E's confirmatory analysis of the pipeway structure adequately addresses and resolves the staff's concerns expressed in the SSER 32. This conclusion is based on the facts that the confirmatory analysis implemented was a detailed time history analysis of the pipeway structure without use of the various approximations which were used in the previous seismic evaluation. Furthermore, the confirmatory analysis is based on acceptable criteria and methodology and demonstrates that the previous results are acceptable. The seismic design adequacy issue of the pipeway structure is closed.

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