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Docket Nos. 50-275
and 50-323

MEMORANDUM FOR: John F. Stolz, Chief, Light Water Reactors Branch No. 1, DPM

FROM: D. Allison, Project Manager, Light Water Reactors Branch No. 1, DPM

SUBJECT: DIABLO CANYON SEISMIC DESIGN

The enclosed ACRS consultant report has been received from John McKinley of the ACRS staff.

The purpose of this memorandum is to provide the report to the parties and the Public Document Rooms.

Original Signed By
Dennis P. Allison

D. Allison
Light Water Reactors Branch No. 1
Division of Project Management

Enclosure:
As Stated

ccs w/enclosure:
See page 2

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DATE➤	7/ /78					

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ccs w/enclosure:

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D. C. 20555

June 23, 1978

C. P. Siess

DIABLO CANYON CONSULTANT'S REPORT

Attached for your review is a copy of a report by our consultant, Mr. T. W. Pickel, regarding the stress evaluation of piping systems of Diablo Canyon. Copies of this report are being provided to the other members of the ACRS and the NRC Staff for their information.

J. C. McKinley, Chief
Project Review Branch No. 1

Attachment:
T. W. Pickel comments dated June 12, 1978

cc: ACRS Members
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M. W. Libarkin, ACRS
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R. Boyd, DDPM (Phil-278)
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UNION CARBIDE CORPORATION
NUCLEAR DIVISION
P.O. BOX X, OAK RIDGE, TENNESSEE 37830

June 12, 1978

RECEIVED
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REACTOR SAFEGUARDS U.S. N.R.C

JUN 14 1978
AM PM
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Mr. John C. McKinley, Chief
Project Review Branch No. 1
US Nuclear Regulatory Commission
Advisory Committee on Reactor
Safeguards
Washington, DC 20555

Dear John:

Stress Evaluation of Piping Systems Assuming
Single Scrubber Failures

As requested, I have reviewed the report entitled "Stress Evaluation of Piping Systems Assuming Single Snubber Failures" which was submitted by Pacific Gas and Electric Company for the Diablo Canyon Unit 1 power plant.

The report addresses a topic of general interest and serves a useful role in helping to quantify the potential effects of seismic snubber failures. The use of a probabilistic evaluation is a desirable approach to the topic. There are questions about the study that need additional consideration, as might be expected, since the data available are limited and the basis for assessment is not firmly established. Four such questions are discussed below.

1. Probability of Snubber Failure

The number of failures assumed in this study represent a substantial improvement in snubber performance in comparison with the data tabulated by Butler and O'Hara (Ref. 1). The number cf failures have been reduced by a factor of 60 in this study. Although some reduction is anticipated, the magnitude assumed in this study creates some uncertainty in the results. A "learning curve" would be expected as the problems associated with snubber failure are recognized and procedures are established for selection, design, installation, testing, and inspection. Designers, manufacturers, and users are making an effort to define and improve performance; however, the quantitative effect of these efforts on failure rates has not been determined. Obviously, additional data are needed to establish failure rates with current procedures before final conclusions can be reached, and the results using present data and assumptions on improvement should be interpreted as having a range of uncertainty.

The analysis approach assumes that the probability of snubber failure is independent of loads and loading history. For most of the failures reported by Butler and O'Hara, this is a reasonable assumption. However, there may be some failure modes that are load or load history dependent. For these cases the method of analysis would need to be modified.

2. Analysis Method

The method used to determine loading conditions for the piping systems involves the use of stress ratios (defined as the ratio of maximum seismic or thermal stress for a piping system with a single snubber failure to the maximum seismic or thermal stress for the same system with all snubbers functioning properly) and stress usage factor (defined as the ratio of the maximum seismic or thermal stress with no snubber failures to an allowable stress value). The stress ratio values were determined for 5 piping systems with a total of 30 snubbers. Stress usage factors were available for 381 lines for the seismic analysis and 361 lines for the thermal analysis. In order to expand the use the stress ratios calculated for the 5 lines to the other lines where stress usage factors were available, distributions were determined for each ratio and the distribution of the product of the two ratios obtained using a Monte Carlo sampling technique. This approach assumes that the stress ratio distribution for the 5 systems evaluated are typical for the 361 or 381 systems and that the stress ratio and stress usage distributions are independent. Some question exists with regard to both of these assumptions. It would be of interest to see the resulting probability of failure for the 5 systems completely analyzed where there is a one-to-one correspondence between stress ratio and stress usage values. For this group of lines the use of the distributions and Monte Carlo technique would not be required.

3. Thermal Failure Criteria

Two questions arise with regard to the thermal failure criteria. First, the number of cycles, n, used in the thermal failure criteria is the number of cycles occurring during 1 year (40 in this particular situation). This is a reasonable basis for determining damage due to snubber failure if a yearly inspection of snubbers is made. However, the damage relationship used in the criteria for piping failure does not properly account for accumulated fatigue damage due to operating cycles prior to snubber failure. Including this accumulated damage in the criteria would increase the probability of piping failure due to thermal cycles occurring with snubber failure.

Second, the failure criteria assume that the probability of failure is linear with respect to fatigue damage. This is probably a conservative assumption, and a more accurate relationship between fatigue damage and probability of failure would be expected to result in a reduction in the probability of piping failure.

These two points tend to counterbalance each other, but the net effect is not obvious without additional study.

4. Seismic Failure Criteria

The justification for the seismic failure criteria established in this study is questionable. The ultimate strength, S_u, of the material is used as the stress below which no piping failures will occur. A stress of 2 S_u is used as the stress above which any pipe will fail. Between these limits a linear failure probability is assumed. A linear elastic fracture mechanics assessment is used to support the failure criteria. As shown by Hsieh and Okrent (Ref. 2), a linear elastic fracture mechanics approach is not adequate when plastic strains accompany cyclic loading. They show that, when plastic strain accompanies cyclic loading, fatigue crack growth may be significant. Thus, the yield strength, S_y, may be a better lower limit than S_u. The upper limit is probably set by the cyclic strain range. It should be noted that for seismic loading, the stresses will normally change sign such that the stress amplitude is roughly half of the stress range. Since the stresses are normally calculated assuming elastic behavior, the upper limit may be 3 to 4 times S_y (strain range of 1.2 to 1.6%).

For materials commonly used in piping systems, strength values under dynamic loading are greater than the strength values for static loading. Increases in strength of 10 to 20% are not unreasonable for seismic loading conditions. Considerations of the dynamic loading conditions and the corresponding increases in material strength might increase the lower and upper limits to 1.2 S_y and 5 S_y, respectively, if the primary stresses are maintained sufficiently low. This change in seismic failure criteria will result in increasing the probability of piping failure due to seismic loading by a factor of approximately two.

In summary, the report addresses a generic question and helps quantify the potential problems associated with snubber failure. Questions exist about snubber failure rates, methods of analysis and piping failure criteria. Additional consideration of these questions is needed before piping failure probability can be determined with a high degree of confidence. At present, uncertainty limits should be established for the various parameters and for the results.

Sincerely,

T. W. Pickel

T. W. Pickel

TWP/blm

cc: C. P. Siess

References

1. J. H. Butler and F. M. O'Hara, Jr., "Analysis of Abnormalities of Snubbers in Nuclear Reactor Service," ORNL/NUREG/TM-53, November 1976.

2. Teh-Ming Hsieh and D. Okrent, "Some Probabilistic Aspects of the Seismic Risk of Nuclear Reactors," UCLA-Eng-76113, December 1976.