Executive Summary
Evaluation of the Core Damage Risk Reduction Associated with Seismic Modifications at the San Onofre Nuclear Generating Station, Unit 1

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

I. INTRODUCTION

San Onofre Nuclear Generating Station Unit 1 has implemented an extensive plant modification program to upgrade the seismic design of safety related structures, systems and components. A probabilistic safety evaluation was performed to assess the improvement (i.e., reduction) in seismic risk that has been realized through this modification program.

The analysis was based upon the methodology of the NRC-sponsored Seismic Safety Margin Research Program (SSMRP) study conducted for the Zion plant. The Zion data used in the SSMRP study was adjusted to account for San Onofre-specific design features. Risk evaluations were performed for the plant in its pre-modification and post-modification states and the net change in seismic risk was evaluated.

Based upon the results of this analysis, the assessed seismic risk associated with the current plant appears to be a factor of 35 to 125 lower than that prior to modification. Even with the large uncertainty associated with seismic risk evaluations of this type, this represents a significant improvement in overall plant safety.

It is estimated that 100 million dollars has been spent in achieving the current design. To reduce the risk further beyond the estimated 2.8×10^{-5}/yr - 2.8×10^{-6}/yr core melt frequency, may not prove cost-beneficial.

II. OVERVIEW OF THE SONGS 1 SEISMIC UPGRADE PROGRAM

As a result of evaluations of the status of the SONGS 1 design and its ability to meet current seismic criteria, a seismic modification program was defined and implemented to upgrade safety-related structures, systems and components. These modifications include the strengthening of the fuel building, intake structure, reactor auxiliary building, and turbine building. Foundations have been upgraded for the turbine building, 480V Switchgear room, and auxiliary feedwater pumps. Piping supports, cable tray supports and tiedowns, containment spray ring piping, and conduit supports were improved. In addition, a new auxiliary feedwater tank was constructed and a new seismically qualified control room ceiling installed.

The objective of this project is to investigate the effect of these modifications on seismic risk. This is done by making use of the results of the SSMRP Zion study and incorporating specific SONGS 1 design features in the analysis.

III. SPECIFIC UPGRADES AND EFFECTS

A number of the identified modifications have potentially significant effects on the overall seismic risk of the plant. The following considerations are pertinent to the SONGS 1 seismic risk evaluation:

- A new auxiliary feedwater system (AFWS) tank was installed to replace the old condensate storage tank. The new tank is designed to meet a 0.67g earthquake design basis.

- Piping supports, conduit supports, cable tray supports and tiedowns, and the control room ceiling were modified. These modifications improve the overall reliability of a number of safety related systems. Because of the limited scope of this study, no detailed investigation of these reliability benefits was made. A sensitivity study was performed to estimate the risk significance of these modifications.

- The turbine building was upgraded to a peak acceleration of 0.67g. The safety significant components affected include steam piping, feedwater piping and parts of the safety injection system piping.

- On-site soil conditions were evaluated and modifications were made to the foundations of the turbine building, 480V Switchgear room, and auxiliary feedwater pumps.

- Masonry wall connections in the reactor auxiliary building were upgraded. As a result of this, portions of piping in the charging system are able to withstand higher earthquake levels.

- The masonry wall evaluation and test program assures that masonry walls will successfully withstand a 0.67g earthquake.

- The intake structure pump well walls were strengthened. This improves the reliability of the saltwater cooling pumps, which in turn improves the reliability of the component cooling water (CCW) system and other systems that the CCW system supports.

- The containment spray rings were modified. This has no effect on core melt frequency.

IV. ANALYSIS OF SEISMIC RISK

A. Alternative Cases

Three cases were analyzed in this evaluation:

- The post-fix SONGS 1 design was evaluated based on best-estimate data, taking credit for improved seismic design of the piping and AFWS tank.

- The post-fix SONGS 1 design was evaluated based on the fragilities derived in the Zion seismic risk study. This represents a conservative estimate because the Zion plant's earthquake design basis is 0.17g, while the corresponding original SONGS 1 design is 0.25g.

- The pre-fix SONGS 1 design was evaluated by assuming a reduction of component and piping fragilities to half the fragility values of the Zion plant. This represents a worst case.

B. Post-Fix Best Estimate

The modifications that have a significant impact on seismic risk include the piping modifications and the new AFWS tank, both designed to 0.67g earthquake levels. To compute component failure probabilities, the fragilities of the tank and piping were scaled up from those of the Zion plant based on the following considerations.

The variability in fragility and response, (i.e., the

logarithmic standard deviation) is assumed to be roughly the same for both the Zion and SONGS 1 plants. If a constant failure probability is specified for the design earthquake level, then the fragility curve is proportional to the design g-level. This is more applicable to structural and project specific design than to procured equipment (the same smaller components may be used for different design g-levels). Piping is usually effected by the project specific installation and support design. Therefore, this is a reasonable assumption for piping. In evaluating the SONGS 1 fragility, two probabilities were used for the likelihood of failure at the design g-level. One evaluation asumed a failure probability for piping at the design g level of 3×10^{-3}. The second evaluation was performed assuming a conservative failure probability of 1×10^{-1}. two failure probabilities were used for piping. One evaluation assumed a failure probability for piping at the design g level of 3×10^{-3}. The second evaluation was performed assuming a more conservative failure probability of 1×10^{-1}.

In the evaluation, sensitivity to failure of components was assessed by evaluating major plant components as being twice as strong as those of the Zion plant. Even so this was a minor effect. The fragility of tanks was increased by a factor of about 3 to account for improved seismic design.

C. Post-Fix, Conservative Case

In this case, the fragility from the Zion study was used with SONGS 1 specific response to compute component failure probability. Since most safety-related components at Zion were designed against a 0.17g level, while those in SONGS 1 were designed against 0.25g/0.5g, this approach is conservative.

D. Pre-Fix Case

Because of the lack of detailed information about piping moments and tank stresses induced by earthquakes and about the fragility of piping and tanks, a worst-case study assuming only half the fragility of Zion counterparts was conducted. It is expected that this analysis provides a conservative estimate of the seismic risk associated with the SONGS 1 plant prior to modification.

V. CONCLUSIONS

The core melt frequency due to earthquake for the three cases is summarized as follows:

Post-fix best estimate	2.8×10^{-6}/yr	(assuming a design g-level piping failure probability of 3×10^{-3})
	1.0×10^{-5}/yr	(assuming a design g-level piping failure probability of 1×10^{-1})
Post-fix conservative	2.8×10^{-5}/year	
Pre-fix	3.5×10^{-4}/year	

This analysis confirms that the seismic risk has been reduced. The uncertainty is not estimated but is known t be large Based upon this evaluation and the asumptions made, the seismic risk has been reduced by about ā factor of 35 to 125 as a result of the SONGS 1 modifications. Even with the large uncertainty associated with seismic risk evaluations of this type, this large reduction in risk represents substantial improvement in SONGS 1 performance under earthquake conditions.