NUREG-1233

# Regulatory Analysis for USI A-40, "Seismic Design Criteria"

## Draft Report for Comment

**U.S. Nuclear Regulatory Commission**

Office of Nuclear Regulatory Research

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Draft Report for Comment

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## ABSTRACT

This report consists of a regulatory analysis for Unresolved Safety Issue (USI) A-40, "Seismic Design Criteria." The regulatory analysis discusses the impact of the proposed changes in the Standard Review Plan (SRP) Sections 2.5.2, 3.7.1, 3.7.2, and 3.7.3 as the resolution.

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## ABBREVIATIONS

| | |
|---|---|
| BNL | Brookhaven National Laboratory |
| CFR | Code of Federal Regulations |
| CP | construction permit |
| ECCS | emergency core cooling system |
| ECI | emergency coolant injection |
| HCLPF | high confidence, low probability of failure |
| ISAP | Integrated Safety Assessment Program |
| LANL | Los Alamos National Laboratory |
| LLNL | Lawrence Livermore National Laboratory |
| LOCA | loss-of-coolant accident |
| NRC | Nuclear Regulatory Commission |
| NRR | Nuclear Reactor Regulation |
| OL | operating license |
| PDA | preliminary design approval |
| PRA | probabilistic risk assessment |
| PSD | power spectral density |
| PWR | pressurized-water reactor |
| RG | regulatory guide |
| RWST | refueling water storage tank |
| SCST | secondary condensate storage tank |
| SEP | Systematic Evaluation Program |

| | |
|---|---|
| SQUG | Seismic Qualification Utility Group |
| SRP | standard review plan |
| SRSS | square root of the sum of the squares |
| SSE | safe-shutdown earthquake |
| SSI | soil-structure interaction |
| SSMRP | Seismic Safety Margins Research Program |
| SSRAP | Senior Seismic Review Advisory Panel |
| SSRS | site-specific response spectra |
| TAP | task action plan |
| USI | unresolved safety issue |

## ACKNOWLEDGEMENTS

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# REGULATORY ANALYSIS FOR USI A-40
# "SEISMIC DESIGN CRITERIA"

## 1 INTRODUCTION

### 1.1 Background

Unresolved Safety Issue (USI) A-40 was initially formulated in 1977 to identify and quantify conservatisms inherent in seismic design criteria for nuclear power plants. Task Action Plan (TAP) A-40 consisted of specific technical studies that concentrated on providing short-term improvements in the current seismic design criteria. Lawrence Livermore National Laboratory (LLNL), under a technical assistance contract, provided a technical overview of the results which were documented in NUREG/CR-1161, "Recommended Revisions to Nuclear Regulatory Commission Seismic Design Criteria," published in May 1980. NUREG/CR-1161 summarizes all technical work accomplished under USI A-40 and makes specific recommendations for changes in seismic design requirements.

In the spring of 1982, the staff reevaluated the status and scope of certain USIs, including A-40. As a result, the procedure for concluding USI A-40 was modified. The changes resulted in: (1) accepting NUREG/CR-1161 as the technical findings of A-40 and (2) NRC technical staff preparing appropriate revisions to the Standard Review Plan (SRP) (NUREG-0800) based on recommendations made in NUREG/CR-1161. The staff, therefore, did not prepare a separate report to present USI A-40 technical findings.

A review group of U.S. Nuclear Regulatory Commission (NRC) staff members from appropriate technical staffs reviewed the recommendations of NUREG/CR-1161 and proposed certain changes to the affected SRP sections. The staff completed the first draft of its revision to the SRP in early 1983. LLNL was the contractor selected to prepare a value/impact assessment for the proposed revision. In August 1984, NUREG/CR-3480, "Value/Impact Assessment for Seismic Design Criteria," was published. The staff also performed additional technical work

in 1984 and 1985 to develop acceptance criteria for use of a single time-history for seismic design. In addition, the staff sponsored a study at Los Alamos National Laboratory (LANL) in 1984 to survey the past performance of above-ground tanks in seismic events and to recommend procedures for analysis. NUREG/CR-4776, "Response of Seismic Category I Tanks to Earthquake Excitation," was published in February 1987 outlining results of this study. The draft report was completed in 1985. The staff also reevaluated the proposed acceptance criteria for soil-structure interaction (SSI) analysis.

In January 1986, the staff decided to modify the proposed regulatory guidance for SSI in the SRP. SSI is a complex and controversial area and the SRP required prescriptive procedures. The staff decided to revise the SRP to include the current state of knowledge in the licensing criteria. To accomplish this, NRC and Brookhaven National Laboratory (BNL) sponsored a workshop (NUREG/CP-0054) at which current technology and procedures regarding SSI in the context of USI A-40 would be discussed. Participants in the workshop were utility personnel, NRC staff, and other researchers and consultants. There was also significant foreign participation. The workshop participants, asked to specifically address the proposed SRP changes and to make suggestions for improvements in the area of SSI, reached a reasonable consensus in each of the technical areas. This consensus forms the basis for the proposed revision in the SSI area.

## 1.2 Work Completed

After reviewing the recommendations made in NUREG/CR-1161 and the information obtained at the SSI workshop, the staff developed specific proposals for revising SRP Sections 2.5.2, 3.7.1, 3.7.2, and 3.7.3. These changes represent an improvement in the analytical methods used in the seismic design of nuclear power plants and will, in some cases, reduce new plant costs by eliminating excessive conservatism. In part, some of the revisions to SRP 2.5.2 reflect current industry practice and staff procedures that have evolved since the Standard Review Plan was issued in 1975. In addition, a number of editorial changes and clarifications were made. The staff also assessed the need for requiring a review of safety-related above-ground tanks.

## 1.3 Value/Impact Analysis

The value/impact analyses included deterministic analyses, qualitative assessments based on engineering experience and judgment, and quantitative probabilistic risk assessment (PRA) analyses where these were possible. Because of the large uncertainties, the PRA analyses (discussed in this report) were not conclusive. The recommendations made are, therefore, based primarily on deterministic and qualitative arguments.

The analyses performed and the staff's qualitative assessments led to the conclusion that for operating reactor and operating license (OL) applicants, the proposed changes to the SRP would have little effect on risk, as plants have generally been and will be seismically upgraded by plant-specific actions such as implementation of the Systematic Evaluation Program (SEP), the proposed implementation of USI A-46, and NRC Bulletin programs. For new construction permit (CP) and preliminary design approval (PDA) applicants, no significant increases in costs are envisioned to implement the proposed SRP sections, and such implementation will lead to more uniform safety margins; therefore, the staff proposes that all new applicants be required to comply with the revised SRP sections.

The analyses also indicated that safety-related, above-ground tanks which were designed using the Housner method (which assumes rigid tank walls) might have less seismic capacity than tanks designed more recently with flexible-wall assumption. The evaluation of above-ground tanks is discussed in the next section.

## 1.4 Recommendation and Implementation

The staff recommends that the changes in proposed revision to SRP Sections 2.5.2, 3.7.1, 3.7.2, and 3.7.3 be issued for public comment. The staff expects that adopting the proposed revision to the SRP sections will achieve the following:

(1) Current staff practices will be reflected. These include:

(a) consideration of site-specific spectra to judge the adequacy of seismic inputs; and

(b) emphasis on neotectonics and seismicity to define tectonic provinces.

(2) Potential sources of nonconservatisms will be eliminated. These include:

(a) provision of additional requirements to determine the adequacy of a single time history for use in plant design;

(b) consideration of higher mode responses in plant design; and

(c) consideration of wall flexibility in the design of large, above-ground tanks.

(3) Possible cost-benefit will be achieved by eliminating or providing alternatives which remove unquantifiable excessive conservatisms, such as:

(a) an option to use multiple time-histories for the plant design;

(b) an option to use direct generation techniques for developing the floor response spectra; and

(c) two broad alternatives, allowing for considerations of state-of-the-art approaches in the SSI area, consistent with the site-specific characteristics.

(4) Greater confidence can be placed on seismic adequacy of nuclear plants by incorporating the knowledge gained as a result of new technological advancements. Such knowledge includes:

(a) consideration of higher mode responses; and

(b) development of methods to account for the wall flexibility in tank design.

On the basis of the findings of the value/impact analysis and the fact that operating reactors have been seismically upgraded by the Systematic Evaluation Program (SEP), by plant-specific actions (e.g., IE Bulletin 80-11),* or by both, the staff recommends that the proposed SRP changes should not be backfitted but should affect new CP and PDA applicants who docket their applications after the revised SRP sections have been approved. These new CP and PDA applicants will be required to design seismic Category I structures, systems, and components to the criteria given in the revised SRP sections.

For certain operating plants, safety-related, above-ground, fluid tanks were identified as a potential backfit requirement. Screening criteria for review of tanks required for safe shutdown are currently being developed by the Seismic Qualification Utility Group (SQUG) under activities related to the implementation of USI A-46, "Seismic Qualification of Equipment in Operating Plants." The NRC staff and the Senior Seismic Review Advisory Panel (SSRAP), which advises the SQUG, will review the screening criteria. The NRC staff anticipates that the implementation of the tank anchorage review guidelines will be sufficient to resolve this concern for the 72 plants that are subject to the requirements of USI A-46. Pages 89 to 98 of NUREG/CR-3480 report on the results of a survey of tank suppliers conducted by Lawrence Livermore National Laboratory. It should be noted that the survey indicates that most tank suppliers have used flexible-wall analysis for a number of years. However, if during the implementation of USI A-46, a plant does not meet the screening criteria or guidelines, or if the screening criteria are not sufficiently definitive to judge tank adequacy for a particular plant, then the need for a plant-specific backfit will be evaluated on a case-by-case basis. No separate action is, therefore, proposed under the resolution of USI A-40 for the plants covered by the requirements of USI A-46.

The remainder of the plants fall into two groups: (1) plants that were subject to licensing review by the staff after or about 1984 and (2) plants that were reviewed by the staff during the period beginning in the late seventies to 1984. For the more-recent plants (Group 1), the NRC staff licensing review

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*IE Bulletin 80-11, "Masonry Wall Design," May 8, 1980.

confirmed that flexible-wall analysis was used and clearly no further action is needed. For the plants in Group 2, a survey of the NRC staff reviewers revealed that tanks for many of these plants were designed using flexible-wall analysis or wall rigidity was not a consideration (reinforced-concrete tanks). However, the status is uncertain regarding analysis technique used for four sites listed below. These four plants (6 units) will be handled on a plant-specific basis by issuing a request-for-information letter under 10 CFR 50.54f.

- Watts Bar 1 & 2
- Callaway 1 & 2
- Wolf Creek 1
- Harris 1

The technical bases for staff recommendation of further consideration of above-ground tanks are the following:

(1) The upgrading of tanks is required to satisfy General Design Criterion 2 (10 CFR 50, Appendix A) which, in part, states that "structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes...without loss of capability to perform their safety functions."

(2) Although the PRA analysis results are inconclusive, the probability of tank failure decreases significantly if the proposed design criteria are used.

(3) The flexible-wall model is more appropriate as it represents a more realistic situation. The use of the Housner method of analysis (rigid-wall assumption) could result in tank designs that underpredict the design forces by a factor of 2.0 to 2.5.

(4) The safety importance of safety-related tanks (particularly the refueling water storage tank (RWST) of pressurized-water reactors) is high. The failure during a seismic event could lead to unacceptable consequences. The recently completed seismic margin study on the Maine Yankee Atomic

Power Station identified the RWST as a component that controlled seismic capacity of the plant. Consequently, the RWST at the Maine Yankee plant has now been upgraded to increase the capacity of the plant. Similarly, seismic risk studies conducted in conjunction with USI A-45, "Decay Heat Removal," have also identified the RWST as a risk-sensitive component for a number of plants.

(5) SEP seismic reviews also identified use of rigid-wall criteria for design of free-standing tanks as a potential safety problem. Most of the field-erected tanks required modifications. Four potential failure modes were identified: (a) anchor bolt overstress because of tension caused by tank overturning moment, (b) weld failure at tank wall and anchor bolt chair, (c) buckling of side wall, and (d) failure of reinforced-concrete foundations. These tanks were designed assuming the tank wall is rigid. Reanalysis considering flexibility of the tank walls identified these potential failure modes.

(6) Surveyors of damage during past earthquakes (NUREG/CR-4776) have repeatedly pointed out the susceptibility of large, above-ground, vertical tanks under earthquake loads. Experience has also confirmed that tanks have failed by the above-mentioned four failure modes (items 5a-5d). Additional failure modes, such as damage to piping and other connecting systems, foundation damage, and buckling of roof and floor plates, have also been observed.

(7) On the basis of experience gained in the SEP review and historical survey of tank performance in actual earthquakes, it is anticipated that only the large, free-standing, metal tanks in the yard (refueling water storage tanks and condensate storage tanks) are of concern for above-mentioned failure modes (items 5a-5d).

## 1.5 Conclusion

The staff has concluded that the proposed actions satisfy the modified objective of USI A-40 to reflect the current state of the art in seismic design in the

licensing process. The assessment of the affect of the proposed changes on plant safety indicates that the changes are warranted and will contribute to a more uniform and consistent licensing process. All the proposed changes in the SRP that constitute the resolution of USI A-40 are to apply to new CP and PDA applicants only.

## 2 VALUE/IMPACT ANALYSIS

The staff has developed specific proposals for changing regulatory guidance in the form of proposed changes to Standard Review Plan (SRP) Sections 2.5.2, 3.7.1, 3.7.2, and 3.7.3 (NUREG-0800). The proposed changes in regulatory requirements are supported by deterministic arguments, qualitative assessments, and by probabilistic risk assessment (PRA) analyses where these are feasible.

The proposed revisions represent an improvement in the analytical methods used in the seismic design of nuclear power plants. These methods will provide greater confidence in the seismic adequacy of structures, systems, and components that are required to withstand the effects of earthquakes in future plants. In some cases, these improved methods will reduce new plant capital costs by eliminating excessive conservatism. The analytical methods used by the industry and the staff have evolved since the Standard Review Plan was issued in 1975. Therefore, some of the proposed revisions reflect current industry design practice and the associated staff review procedures. Also, editorial changes and clarifications were made.

The staff prepared the value/impact assessment for the proposed revision to SRP Section 2.5.2. For SRP Sections 3.7.1, 3.7.2, and 3.7.3, Lawrence Livermore National Laboratory (LLNL) assisted the staff in preparing the value/impact assessment. The value/impact analyses for SRP Sections 3.7.1, 3.7.2, and 3.7.3 are presented in Section 2.1 of this report. The value/impact analysis for SRP Section 2.5.2 is presented in Section 2.2 of this report.

## 2.1 Value/Impact Analysis for Proposed Revision to SRP Sections 3.7.1, 3.7.2, and 3.7.3

### 2.1.1 The Proposed Actions

#### 2.1.1.1 Summary of Issue

Structures, systems, and components important to the safety of nuclear power plants are required to withstand the effects of natural phenomena such as earthquakes. Broad requirements for earthquake resistance are indicated in Title 10 of the Code of Federal Regulations (10 CFR), Parts 50 and 100. Detailed guidance as to the acceptable ways of meeting these requirements is given in various regulatory guides. Safety analysis reports for each plant are reviewed in accordance with the review and acceptance criteria described in the Standard Review Plan.

Early nuclear power plants were designed without specific seismic design requirements. In the early 1970s, the requirement for seismic resistance was mentioned in the regulation. The state of knowledge has advanced rapidly, and there are generations of nuclear power plants that have various levels of seismic design requirements. Also, the complex process of seismic design involved many engineering disciplines--seismic, geotechnical, structural, mechanical, electrical, and nuclear. Each discipline in the design process controlled the design parameters in its domain. As the total seismic design process evolved, two questions emerged:

(1) How adequate are the plants in earlier generations with respect to current safety requirements?

(2) What is the margin of safety in the overall seismic design process?

USI A-40 was initiated to address these questions. NRC Task Action Plan A-40 (TAP A-40) stated the objectives as "to investigate selected areas of the seismic design sequence to determine their conservatism for all types of sites, to investigate alternate approaches to parts of the design sequence, to quantify

the overall conservatism of the design sequence, and to modify the NRC criteria in the Standard Review Plan if changes are found to be justified." The seismic designs of some of the older reactors were reviewed as part of the Commission's Systematic Evaluation Program (SEP). Technical work completed as part of TAP A-40 contributed significantly to those reviews. Criteria in the Standard Review Plan serve as the safety baseline for seismic re-review, even though specific compliance is not required.

Studies under the USI A-40 program included the following: (1) quantification of conservatism in seismic design, (2) elasto-plastic, seismic analysis methods, (3) site-specific, response spectra, (4) nonlinear, structural, dynamic-analysis procedures, and (5) soil-structure interaction. Technical findings of USI A-40 are presented in "Recommended Revisions to Nuclear Regulatory Commission Seismic Design Criteria" (NUREG/CR-1161). In that report, the contractor reviewed all technical work performed under the A-40 program, as well as other pertinent information, and developed specific recommendations for Standard Review Plan changes. During staff review of the contractor's recommendations, a consultant was hired to develop acceptance criteria for review of single, time-history applications. These criteria took the form of a "target" power spectral density function, as included in the proposed revision to SRP Section 3.7.1 .

As the TAP A-40 tasks were completed, industry and staff practices were revised to include consideration of the improved procedures; therefore, the Standard Review Plan does not adequately reflect the current state of technology. For this reason, many of the proposed changes have no impact because they serve to update the SRP to reflect current understanding and practice.

2.1.1.2 Recommendations

The staff has completed its review of the recommendations made in NUREG/CR-1161. Many of the recommendations were accepted by the staff; a few were rejected for various reasons. Those recommendations that have been accepted are included in the proposed revision to SRP Sections 3.7.1, 3.7.2, and 3.7.3. Therefore, the proposed action is to revise and issue these SRP sections.

The staff recommends that the revised Standard Review Plan be implemented only on new CP and PDA applications docketed after the effective date of the revisions. The primary reasons for this recommendation are given below:

(1) The intent of the USI A-40 study was to survey the state of the art and to upgrade the Standard Review Plan to reflect current understanding of seismic design principles and procedures. The investigations described in NUREG/CR-1161 and results of the staff's regulatory analysis led to the conclusion that backfitting is not required.

(2) In addition, the proposed revision, in some cases, reflects current industry design practices and thus, to some extent, does not affect industry design or analysis procedures.

(3) Although some older sites were designed to seismic criteria less rigorous than current requirements, significant upgrading has been or will be achieved by the SEP, the implementation of the USI A-46 resolution, and by staff Bulletins and Information Notices (e.g., IE Bulletin 80-11, "Masonry Wall Design").

(4) The Standard Review Plan serves as a safety baseline in re-review programs such as the SEP and for disposition of plant-specific concerns in the event a seismic design consideration is identified.

In summary, the staff proposes to issue revised SRP Sections 3.7.1, 3.7.2, and 3.7.3 for implementation on CP and PDA applications docketed after the revision is issued.

2.1.1.3 Need for the Proposed Actions

The SRP changes are needed to upgrade seismic design requirements and to reflect current staff review practice.

2.1.1.4 Basis for the Proposed Actions

Consideration of the NUREG/CR-1161 recommendations resulted in a total of 24 proposed changes to SRP Sections 3.7.1, 3.7.2, and 3.7.3. Some of the proposed changes represent alternative procedures or clarifications of existing requirements. For these cases, no explicit estimate of change in risk or cost was deemed necessary. Of the 24 proposed changes, 14 have a potential benefit or impact, and a value/impact assessment was performed. The assessment was qualitative in some cases where it was not practical to conduct PRA analyses. The 14 proposed changes were combined into 7 task areas for the purpose of conducting the analyses. The proposed changes are summarized below, grouped into 7 areas. The change numbers (from Table 1) are shown for each area. More than one change number for an area means that both the review procedures and acceptance criteria sections were changed in the SRP. Change numbers that do not appear in the list below are either optional or editorial changes.

Area 1 Design Time-History--Change No. 6

Area 2 Development of Floor Response Spectra and Effects of Parameter Variations on Floor Response Spectra--Changes No. 16 and 18.

Area 3 Percentage of Critical Damping Values--Change No. 8

Area 4 Soil-Structure Interaction--Changes No. 11 and 15

Area 5 Seismic Analysis Methods and Combination of Modal Responses--Changes No. 13, 14, and 17

Area 6 Methods for Seismic Analysis of Above-ground Tanks--Changes No. 20, 23, and 24

Area 7 Category I Buried Piping, Conduits and Tunnels--Changes No. 21 and 22

Only Areas 1, 5, and 6 (above) were reviewed in detail to assess potential value/impact. PRA analyses were conducted only for Areas 5 and 6. Proposed changes related to Areas 2, 3, and 7 were determined to result in insignificant impact. In many cases, the proposed changes represent options or clarifications of existing NRC requirements. Although these changes do not result in appreciable impact, they are proposed because they reflect current industry practices and the state of the art. These changes are discussed in NUREG/CR-3480.

Table 1 Summary of proposed changes to SRP Sections 3.7.1, 3.7.2, and 3.7.3

| Number | SRP Section | SRP topic | Change in requirements | Potential impact |
|---|---|---|---|---|
| | 3.7.1 | | | |
| 1 | 3.7.1.I.1.a | Design response spectra | Editorial. | None. |
| 2 | 3.7.1.I.1.b | Design time history | Option to use multiple time histories is given. | Review not required since change represents an option. |
| 3 | 3.7.1.I.4 | Staff coordination with other branches | Response spectra at foundation level reviewed. | None, since 3.7.1.II.1.b already requires this. |
| 4 | 3.7.1.II.1.a | Design response spectra | Design response spectra should meet or exceed amplitudes of site-specific spectra at all frequencies. | None, since requirement already exists. |
| 5 | 3.7.1.II.1.a | Design response spectra | Editorial, reference to 2.5.2. | None. |
| 6* | 3.7.1.II.1.b | Design time-history | Justification for use of single time-history required, and use of multiple time-histories given as option. | Value/impact assessment conducted. |
| 7 | 3.7.1.II.2 | Critical damping values | Effect of pore pressure on soil is to be considered. | Review not required since change is clarification of current requirements. |
| 8 | 3.7.1.II.1 | Critical damping values | Notification that compliance with stress provision in RG 1.61 will be reviewed. | Review not required since change is clarification of current requirements |
| 9 | 3.7.1.III.1 | esign ground motion | Editorial. | None. |

*Indicates proposed changes for which value/impact assessments were made.

Table 1 (Continued)

| Number | SRP Section | SRP topic | Change in requirements | Potential impact |
|---|---|---|---|---|
| 10 | 3.7.1.IV | Evaluation findings | Evaluation findings modified for use of single or multiple time histories. | None. Changes relate to SRP option. |
| | 3.7.2 | | | |
| 11 | 3.7.2.I.4 | Soil-structure interaction | Uncertainties must be "recognized." | Review not required since change is clarification of current requirements. |
| 12 | 3.7.2.I.5 | Development of floor response spectra | Various new methods allowed. | None. New methods are optional. |
| 13* | 3.7.2.II.1(4) | Seismic analysis method | Acceptance criteria for adequacy of number of degrees of freedom modified. | Value/impact assessment conducted. |
| 14* | 3.7.2.II.1(5) | Seismic analysis method | Demonstration required to show that high-frequency effects are included. | Value/impact assessment conducted. |
| 15* † | 3.7.2.II.4 | Soil-structure interaction | Two broad alternatives given--one alternative eliminates enveloping of results from two different SSI analyses as required in current SRP version. Input ground motion is not required to be at the foundation level. Uncertainties to be "addressed" are listed. | Value/impact assessment conducted. |

*Indicates proposed changes for which value/impact assessments were made.

†Significant revision has been made in the area of SSI analysis since the LLNL reported value/impact assessment in NUREG/CR-3480L. The discussion in Section 3.4 of NUREG/CR-3480 is no longer applicable. A qualitative value/impact resulting from the proposed changes is included in this report.

Table 1 (Continued)

| Number | SRP Section | SRP topic | Change in requirements | Potential impact |
|---|---|---|---|---|
| 16* | 3.7.2.II.5 | Development of floor response spectra | Single time-history use to be justified. Use of multiple histories reviewed on case-by-case basis. Direct generation methods reviewed. | Value/impact assessment conducted. |
| 17* | 3.7.2.II.7 | Combination of modal responses | Acceptance criteria for consideration of high-frequency modes given in new Appendix | Value/impact assessment conducted. |
| 18* | 3.7.2.II.9 | Effects of parameter variations on floor response spectra | Acceptance criteria for parameter variations referred back to SRP 3.7.2.II.5 | Value/impact assessment conducted. |
| 19 | 3.7.2.IV | Evaluation findings | Editorial change to include Category I above-ground tanks. | None. |
| | 3.7.3 | | | |
| 20* | 3.7.3.I.14 | Methods for seismic analysis of above-ground tanks | New topic. Fluid dynamics and tank flexibility included. | Value/impact assessment conducted. |
| 21 | 3.7.3.II.12(1) | Category I buried piping, conduits, and tunnels | Specifically states the kinds of ground-shaking, induced loadings to be considered. | Review not required since change is clarification of current requirements. |
| 22 | 3.7.3.II.12(3) | Category I buried piping, conduits, and tunnels | Specifically states the kinds of seismic-induced loadings to be considered. | Review not required since change is clarification of current requirements. |

*Indicates proposed changes for which value/impact assessments were made.

Table 1 (Continued)

| Number | SRP Section | SRP topic | Change in requirements | Potential impact |
|---|---|---|---|---|
| 23* | 3.7.3.II.14 | Methods for seismic analysis of above-ground tanks | New topic. Fluid dynamics and tank flexibility must be included. Rigid wall assumption not allowed in some cases. | Value/impact assessment conducted. |
| 24* | 3.7.3.III.14 | Methods for seismic analysis of above-ground tanks | New topic. Methods of seismic analysis are reviewed. | Value/impact assessment conducted. |

*Indicates proposed changes for which value/impact assessments were made.

The remaining area (Area 4), "Soil-Structure Interaction," has been substantially revised since NUREG/CR-3480 was published, and the value/impact contained in Section 3.4.3 of that report is no longer applicable. The revised position is more consistent with the recommendations made in NUREG/CR-1161 and, additionally, reflects the recommendations and findings resulting from a staff-sponsored workshop on the subject of the soil-structure interaction analysis held in Bethesda, Md., on June 16-18, 1986. The proceedings of the workshop on soil-structure interaction are published in NUREG/CP-0054. It should be noted that the revised position is also consistent with the technical discussion of issues contained in Section 3.4.2 of NUREG/CR-3480. A qualitative value/impact assessment for area 4 is included after the discussion of Areas 2, 3, and 7. Areas 1, 5, and 6 are discussed below.

Area 1

The proposed requirements in Area 1, "Design Time-History," specify that single, artificially generated time-histories meet not only the existing requirements concerning the envelopment of target response spectra but also that power spectral density (PSD) functions generated from these time-histories match a target PSD function. An evaluation of 14 artificial time-histories [corresponding to Regulatory Guide (RG) 1.60 spectra], used by architect/engineer firms and licensees to satisfy the current SRP criteria, indicate that these records generally exceed staff PSD requirements at frequency ranges of general interest for the design of nuclear power plants (i.e., 20 Hz and less). However, as shown in Figure 1, some of the currently used time-histories do exhibit occasional dips below the required PSD level in the low-frequency range (less than 20 Hz) and exhibit general low level of energy in the high-frequency range, although they meet the response spectra enveloping requirements (Figure 2). Thus, this requirement will eliminate a potential source of nonconservatism.

As discussed above, the time-histories used satisfy the proposed PSD requirements over the significant frequency ranges for structure response. This implies that many of the operating plants and plants under operating license (OL) review have met at least the intent of the proposed SRP change pertaining to the use of a single time-history and, therefore, no significant change in plant risk can be expected from implementation of the proposed change to these plants. In light

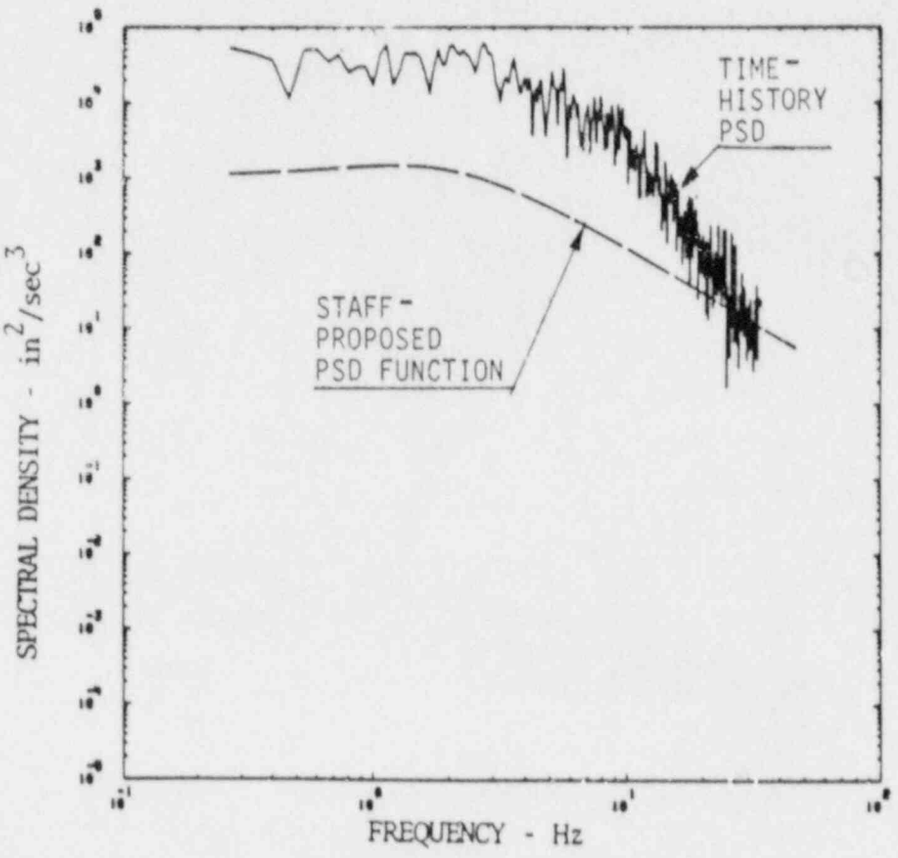


Figure 1 Artificial horizontal time-history PSD vs. staff-proposed criterion

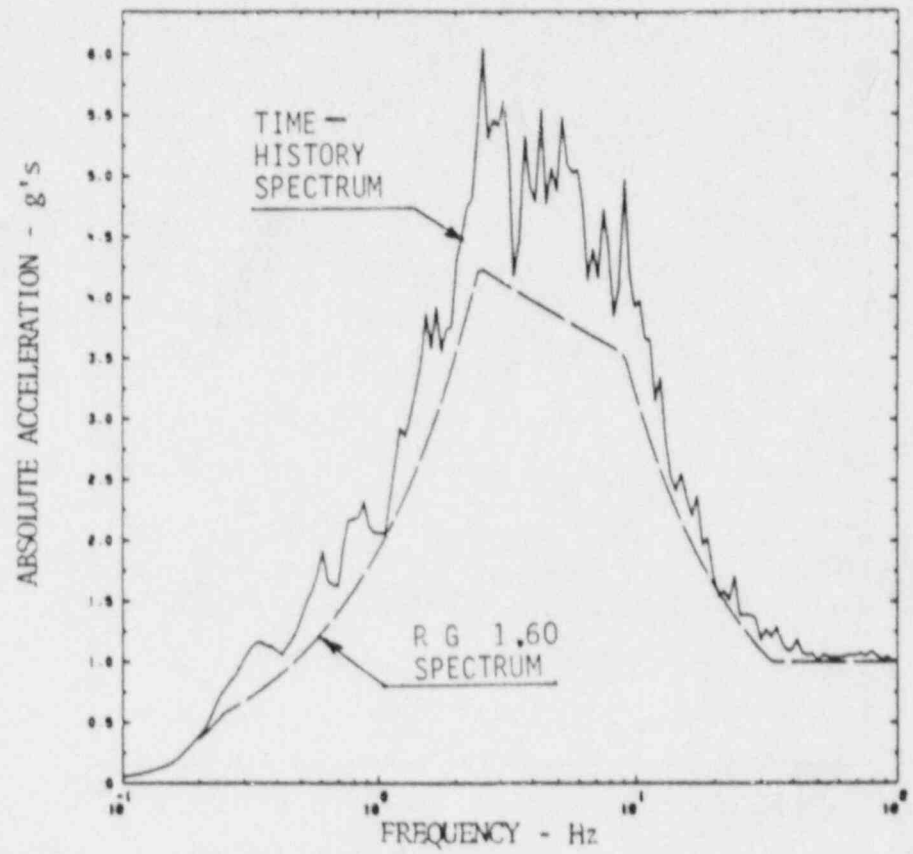


Figure 2 Artificial horizontal time-history 2% response spectrum vs. RG 1.60 spectrum

of this, the staff has concluded that the proposed change need not be backfitted to operating plants and plants under OL review. However, the adoption of the change will eliminate a potential source of nonconservatism and, therefore, a forward fit of the proposed change is recommended for future CP and PDA applicants. Only a small additional cost would be anticipated to implement this requirement, i.e., the cost to compare PSDs and, perhaps, the cost of regenerating artificial time-histories to meet the criteria in the frequency range greater than 20 Hz. The cost to the licensee of regenerating artificial time-histories would represent a small, one-time analysis cost. Additional review time associated with the PSD requirement would be approximately 3 staff-weeks. Thus, estimated analysis and review costs associated with this proposed new requirement are small and considered insignificant.

In summary, the survey of currently used time-histories indicates that these time-histories, generally, meet the intent of the proposed staff requirement and do not represent a significant safety issue. Therefore, the proposed change does not warrant backfit considerations. However, the need to qualify the use of a single, artificial time-history, with respect to a proposed target PSD function, will identify potential nonconservatism in energy content of the time-history; therefore, a forward fit for this proposed change is recommended.

Area 5

The proposed change in Area 5, "Seismic Analysis Methods and Combination of Modal Response," requires that special consideration be given to the responses associated with high-frequency modes when the response spectrum method of analysis is used. To assess the impact of this change on seismic risk, the PRA analysis performed on the Zion Nuclear Plant, as part of the Seismic Safety Margins Research Program (SSMRP) Phase II study, was used as a base case. This proposed change would affect all Category I structures in the plant. It was not feasible to change the entire SSMRP model to represent the effects of the proposed change. Instead, one representative structure was selected to demonstrate the effect on risk. The structure selected was a critical shear wall in the Zion auxiliary building. On the basis of recent studies cited in the contractor's report,

NUREG/CR-3480, it was determined that, if the proposed methods of mode combination were applied, the wall stresses might increase by as much as 33%. The fragility of the critical shear wall in the auxiliary building was, therefore, modified by 33% over the wall strength used in the base-case, SSMRP study.

Table 2 summarizes results of the probabilistic risk assessment (PRA) analysis. Results of this analysis indicate that by increasing the wall strength (because of the proposed requirement), the probability of failure of the shear wall decreases significantly. This decrease is an imposed change that results from adjustments in the fragility curve. The resulting change in core-melt probability is very small and the change in release is undetectable. No conclusions on incremental risk due to imposing the proposed requirement on the entire plant can be drawn from these results.

Although the shear wall of auxiliary building is the most significant component that is relevant to this task, it is not a major contributor to risk. From Table 2 it can be seen that, even before the wall is strengthened, the conditional failure probability is negligible at the two lowest earthquake levels. Other structural failures exist which dominate. They are uplift of the containment basemat and collapse of the service water cribhouse roof.

Plants different from Zion may not be subject to these other structural failures. For those plants, the failure of a wall similar to the auxiliary building's shear wall at Zion could be a dominant contributor to risk. The severing of electrical and fluid lines and the impacting of debris on adjacent equipment can be important common-mode failures of vital safety systems. Thus, strengthening vital walls should be considered an important seismic safety improvement.

The impact of the proposed SRP changes would be to eliminate this possible, but generally unlikely, source of nonconservatism in design. The change would make clear the cause of this nonconservatism and would eliminate the need for the use of approximate methods, which have been used in the past to correct this deficiency. Once computer programs are modified, the added analytical costs and engineering efforts would be small. Furthermore, no construction changes in future plants are anticipated as a result of the proposed revision. In general, seismic shear stresses in reinforced-concrete walls are well below allowable stresses, and a 33% increase in these stresses would not affect wall design.

Table 2 Auxiliary building shear wall

| EQ level | P-fail$_0$ | P-fail$_1$ | P-CM$_0$ | P-CM$_1$ | Mrem$_0$ | Mrem$_1$ |
|---|---|---|---|---|---|---|
| .06-.10g | 0. | 0. | 3.7E-8 | 3.7E-8 | 2.9E-3 | 2.9E-3 |
| .10-.20g | 1.33E-9 | 1.94E-12 | 1.8E-8 | 1.8E-8 | 1.5E-3 | 1.5E-3 |
| .20-.32g | 6.96E-6 | 2.09E-8 | 2.8E-5 | 2.8E-5 | 5.3E+0 | 5.3E+0 |
| .32-.42g | 7.43E-4 | 5.03E-6 | 1.2E-6 | 1.2E-6 | 3.7E+0 | 3.7E+0 |
| .42-.53g | 2.76E-2 | 1.59E-3 | 5.2E-7 | 5.2E-7 | 1.2E+0 | 1.2E+0 |
| .53-.69g | 8.76E-2 | 7.22E-3 | 2.0E-7 | 1.9E-7 | 5.9E-1 | 5.9E-1 |

EQ level = earthquake acceleration range for which values are applicable;
P-fail = conditional probability of shear wall collapse;
P-CM = annualized probability of core melt due to an earthquake of this level;
Mrem = total risk in man-rem/year from an earthquake within the given level.

The remaining variables are subscripted with either "0" or "1". A "0" subscript column represents the original value before the component strength was modified. A "1" subscript column represents the postmodification value.

The column "P-fail" represents the conditional component failure probability. By conditional is meant the probability does not include the probability of occurrence of an earthquake in the specified range. The column "P-CM" represents the annual probability of core melt. The column "Mrem" represents the total contribution to risk, in man-rem/year, from the specified earthquake level. Both the core-melt and man-rem values are unconditional. That is, they do include the annual probability of occurrence of an earthquake in the specified range.

It is also believed that the maximum increase in the base-of-wall, overturning moments of approximately 10% would not lead to any appreciable changes in wall reinforcement.

An additional 2 staff-weeks of effort might be required to review changes in analysis resulting from the adoption of this proposed new requirement. The total cost increases associated with this requirement are not expected to exceed $5000 (estimated in 1985) for new plants.

The staff recommends that this requirement should be applied to new applications because, as discussed above, this requirement, in general, will not enhance the safety of existing structures and the reanalysis of existing structures would

be very costly. Therefore, the proposed change does not warrant backfit considerations. However, the proposed change would eliminate a possible source of nonconservatism in design with a very moderate increase in cost. On the basis of these considerations, a forward fit is recommended to new applications.

Area 6

For Area 6, "Methods of Seismic Analysis of Above-ground Tanks," the proposed revision to SRP sections requires that dynamic effects and tank-wall flexibility be considered in the analysis of above-ground tanks. As discussed in NUREG-3480, the regulatory analysis for Area 6 was performed by conducting the risk analysis using the Zion SSMRP model. Initially, the analysis was performed on the secondary condensate storage tank (SCST). Subsequently, additional studies were made on the refueling water storage tank (RWST) using various assumptions. However, the results of these studies were inconclusive in terms of estimating changes in man-rem releases and depended heavily on assumptions made regarding post-core-melt phenomena (containment failure mode and release category assignments).

Notwithstanding the inconclusive nature of the value/impact study reported in NUREG/CR-3480, some recent seismic risk and margin studies, and observation of the performance of tanks in earthquakes, as discussed below, support the proposed revision to SRP sections.

(1) Although the PRA analysis results are inconclusive, the probability of tank failure decreases significantly if the proposed design criteria are used.

(2) The flexible-wall model is more appropriate as it represents a more realistic situation. The use of the Housner method of analysis (rigid-wall assumption) could result in tank designs that underpredict the design forces by a factor of 2.0 to 2.5.

(3) The safety importance of safety-related tanks [particularly the condensate storage tank (CST) and the refueling water storage tank (RWST) of

pressurized-water reactors] is high. Failure of such tanks during a seismic event could lead to unacceptable consequences. The recently completed seismic margin study on the Maine Yankee Atomic Power Station identified the RWST as a component that controlled seismic capacity of the plant. Consequently, the RWST at Maine Yankee has now been upgraded to increase the capacity of the plant. Similarly, seismic risk studies conducted in conjunction with USI A-45, "Decay Heat Removal," have also identified the RWST as a risk-sensitive component for a number of plants.

(4) SEP seismic reviews also identified use of rigid-wall criteria for design of free-standing tanks as a potential safety problem. Most of the field-erected tanks required modifications. Four potential failure modes were identified: (a) anchor bolts overstress because of tension caused by tank overturning moment, (b) weld failure at tank wall and anchor bolt chair, (c) buckling of side wall, and (d) failure of reinforced-concrete foundations. These tanks were designed assuming the tank wall is rigid. Reanalysis considering flexibility of the tank walls resulted in the identification of these potential failure modes.

(5) Surveyors of damage during past earthquakes (NUREG/CR-4776) have repeatedly pointed out the susceptibility of large, above-ground, vertical tanks under earthquake loads. Experience has also confirmed that tanks have failed by the above-mentioned four failure modes (items 4a-4d). Additional failure modes such as damage to piping and other connecting systems, foundation damage, and buckling of roof and floor plates have also been observed.

On the basis of this discussion, the staff recommends that the proposed changes in tank design should be incorporated in the Standard Review Plan and should be applied to new applications (forward fit). As discussed in the Introduction, the review of the safety-related, above-ground tanks necessary for safe shutdown in operating plants will be conducted under the implementation of the USI A-46 program and other reviews. No separate action is, therefore, proposed under the resolution of USI A-40.

Areas 2, 3, and 7

Quantitative value/impact assessments were not prepared for proposed changes in Areas 2, 3, and 7. However, qualitative arguments were made in the contractor's report for proposed changes in these areas. The following is a brief summary of these qualitative assessments.

For Area 2, "Development of Floor Response Spectra and Effects of Parameter Variations on Floor Response Spectra," it should be noted that the proposed requirements relate to the justification for the use of a single time-history in design and, as such, the value/impact is the same as discussed for Area 1 and the argument for no need to backfit this proposed change is same as for Area 1. The proposed options for the use of multiple time-histories for the direct generation of floor spectra are likely to result in removing unnecessary conservatisms for piping systems and equipment.

The proposed changes in Area 3, "Percentage of Critical Damping Values," are editorial in nature and clarify the current staff review practices; therefore, they have no impact on the industry or staff and do not require backfit considerations. NUREG/CR-3480 contains detailed technical discussions for this area.

The proposed changes in Area 7, "Category I Buried Piping, Conduits and Tunnels," clarify current staff requirements. Additional guidelines are given for the selection of parameters to be used in the design of underground piping structures. No impact on the industry or staff will result from the proposed changes. Therefore, the proposed changes do not require backfit considerations.

In summary, the proposed changes in Areas 2, 3, and 7 are editorial and clarify the staff review practices and, therefore, will not have significant impact on plant designs or risks. No backfitting is recommended for this reason. However, the adoption of the proposed changes will result in smoother reviews, and will serve as a baseline when a plant-specific seismic issue emerges.

Area 4

The proposed revision in Area 4, "Soil-Structure Interaction," provides two broad alternatives to perform the soil-structure interaction (SSI) analyses rather than the very prescriptive, procedure-oriented, acceptance criteria in the current SRP.

(1) Alternative 1

The first alternative is very similar to current acceptance criteria, with one significant change. This change relates to the location at which the ground motion input is to be applied for the SSI analyses. The proposed revision no longer requires that the design ground motion for the SSI analyses should be applied at the foundation level in the free field; rather, it should be applied at the free ground surface or rock outcrop (real or hypothetical) as recommended in NUREG/CR-1161. The staff's current position of requiring ground motion to be specified at the foundation level in the free field resulted from licensing review experience in the mid-seventies. At that time, the practice was to apply a broad-band, non-site-specific spectrum at the free ground surface and deconvolve down to a depth. This practice, in some cases, led to significant suppression or deamplification of spectra in the frequency range of interest at the foundation level. The Advisory Committee on Reactor Safeguards (ACRS) convened a meeting with the staff and industry experts in February 1977 to discuss these concerns. No definite conclusions were reached at that meeting, but it was clear that at some sites (e.g., site with a thin soil layer overlying a hard stratum) the use of deconvolution required caution. Since the mid-seventies, a number of studies have been conducted to address this concern. Also, because of better understanding of geology and seismicity the use of site-specific spectra is more feasible and is the preferred input for seismic analyses (see Section 2.2). With the use of site-specific spectra, the uncharacteristic "dip" in the spectra at the foundation level is eliminated.

The staff sponsored a workshop on SSI in June 1986 to discuss this issue in detail (NUREG/CP-0054). It was generally agreed in the SSI workshop

that the staff's current position regarding the input location of the ground motion results in excessive conservatism in many situations and, particularly, for deeply embedded structures. The current staff acceptance criteria endorse the practice of neglecting the variations of ground motion with depth, also characterized as neglecting "kinematic interaction" but retaining "inertial interaction." This effect of neglecting kinematic interaction on the structural response was also investigated in a recently completed study (NUREG/CR-3805, Volumes 4 and 5, "Engineering Characterization of Ground Motion," August 1986) by performing calculations for the reactor building of a PWR plant with two embedment depths (20 feet and 40 feet), four soil profiles, and four seismic excitations. Calculations were performed including and excluding "kinematic interaction" effects. Figure 3 illustrates comparison of floor response spectra with and without kinematic interaction effects for a broad-band (RG 1.60) excitation and a soil profile that represents a layered soil site having a softer upper 40-foot layer with a shear wave velocity of 1000 ft/sec overlaying a soil layer with a shear wave velocity of 1800 ft/sec. The kinematic interaction or geometrical effects lead to averaging and thus reduction of the high-frequency portion of the translational component of the excitation. This effect, on the other hand, also induces the rocking motion of the massless foundation. The conservatism of neglecting the kinematic interaction effects is apparent and is greater for seismic excitations rich in high frequencies. In Volume 5 of NUREG/CR-3805, therefore, the authors concluded the following:

- The practice of excluding ground motion variations with depth, as has been done in a number of instances in nuclear power plant design practice, is not founded on a physical basis and appears to uniformly lead to additional conservatism and overestimation of structural response.

- On the basis of these studies, it is concluded that appropriate variations of ground motion with depth should be included in characterizing foundation input motions and carrying out soil-structure interaction analyses for embedded structures. Current analysis procedures that incorporate deconvolution of ground surface motions in the free field

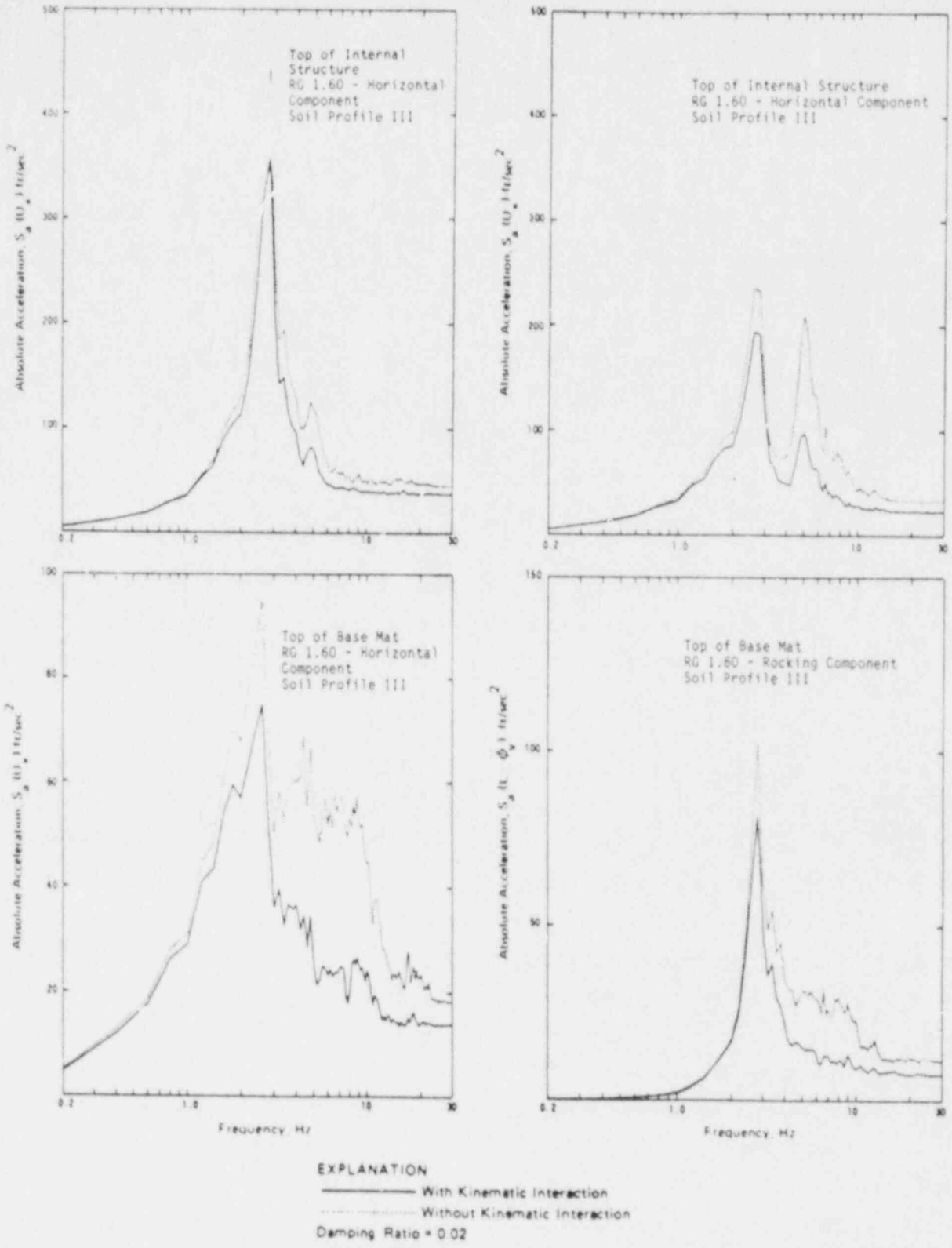


Figure 3 Comparison of floor response spectra of reactor building from analyses with and without consideration of kinematic interaction, artificial RG 1.60 excitation (40-foot embedment, vertical incidence)

may appropriately be used. It is also concluded that incorporating soil property variations in parametric deconvolution and soil-structure interaction analyses is an appropriate way not only to incorporate effects of uncertainties in the properties on foundation stiffness and inertial interaction, but also to reasonably incorporate effects of uncertainties in the characterization of ground motion variations with depth.

In addition, the proposed position is more consistent with the physical phenomena and recorded data leading to more consistent results. In Volume 3 of NUREG/CR-3805, the recorded earthquake and experimental data were studied to investigate spatial variations of earthquake ground motions. Again, in Volume 5, the authors concluded the following:

- There is a good body of data to show that, in general, both peak accelerations and response spectra decrease significantly with depth in the depth range of typical embedment depths of nuclear power plant structures.

- Comparisons of data and analysis indicate that deconvolution procedures assuming vertically propagating shear waves provide reasonable and apparently somewhat conservative estimates of the variations of ground motion with depth. The current practice of conducting deconvolution analyses incorporating rather wide parametric variations in soil shear modulus appears to result in conservative estimates of the variations of ground motion with depth.

The staff's proposed position now allows for the variation of motion with depth and kinematic interaction effects; thus, the impact of Alternative 1 can be summarized as one leading to removal of excessive conservatism in the current staff acceptance criteria.

(2) Alternative 2

Alternative 2 allows for greater latitude in the selection of appropriate SSI methodology with more extensive site investigations. This alternative

would allow the plant designers to exercise state-of-the-art approaches consistent with the site-specific considerations. It is estimated that this alternative will lead to removal of excessive conservatism which results from the current staff acceptance criteria; however, in some cases, additional analysis effort may be required.

A qualitative regulatory analysis is performed based on the past experience and seismic PRA results to assess the impact of the proposed changes in the SSI area. The staff judges that the proposed SRP revision removes some arbitrary excessive conservatism from the current requirements, which is likely to lead to lesser design requirements for the mechanical components and piping systems. However, the effects on the structural components and on the seismic risk estimates are considered negligible for the following reasons:

(a) A number of recently licensed plants (OL) were designed to 1975 SRP requirements which specified the free-field motion at the free surface for SSI analysis. During the OL review, the implementation of the current position of input motion at the foundation level in the free field resulted in a modification of some structural floor beams of seismic Category I structures at one plant. No hardware changes resulted at other plants. (Note that the staff's investigation was limited to the safe-shutdown systems and structures that housed them, and allowance was made for tested strength values in some cases.)

(b) The design of structures or components is not governed by the seismic loads alone. For example, the thicknesses of exterior walls are more often controlled by tornado missile protection requirements.

(c) The comparison in Figure 3 represents an analytical study to estimate the effects of neglecting kinematic interaction. In actual design process, the explicit consideration of uncertainties and variation of parameters required in the proposed SRP will lessen the differences.

(d) The seismic PRAs and safety margin studies have generally shown considerable margin in the seismic Category I structures and components

beyond the design basis. Any small change in the margin is not likely to have any meaningful impact on the seismically induced core melts or offsite consequences of radioactive release as the uncertainties in both the hazard and fragility estimates are still large. In many cases, the seismic risk results from interaction between non-Category I and safety-related systems (e.g., Indian Point Station, Unit 2, control building impact) or non-analysis-controlled aspects of design (e.g., vertical shafts of the service water pumps at Zion).

In summary, the impact on the industry is the removal of arbitrary conservatism in the current SSI analysis procedures, thus, leading to lesser design requirements with slightly greater engineering effort. The impact on the staff is the increase in the review time, as the proposed revision allows for new developments and calls for more rigorous consideration of uncertainties. This change does not warrant backfit considerations.

2.1.1.5 Value/Impact Assessment of Proposed Actions

Impact on Industry and NRC

A summary of industry and NRC impact is provided in Table 3. NRC impact is limited to additional review time.

Other Government Agencies

Since the seismic design review and acceptance is carried out solely by NRC staff, no impact on other government agencies is projected.

Public

The following describes "value" to the public in a qualitative sense if the proposed revision to SRP sections is adopted.

Possible reduction in new plant capital costs by eliminating or providing alternatives which may remove unquantifiable excessive conservatisms.

Table 3 Industry and NRC impact resulting from proposed changes in SRP Sections 3.7.1, 3.7.2, and 3.7.3

| SRP Section and review area | Proposed changes | Industry impact | NRC impact (additional review time) |
|---|---|---|---|
| 3.7.1, Area 1 | Design time-history (additional justification of the use of single time-history by satisfying PSD requirements) | Minor industry impact as currently used time-histories satisfy PSD requirements on frequency range up to 20 Hz. However, additional adjustments to satisfy requirements in high-frequency area will be needed. Additional computation effort will be required. | ~3 staff-weeks |
| 3.7.2, Area 2 | Development of floor response spectra and effects of parameter variation on floor response spectra | Impact same as above. | Included in above item |
| 3.7.2, Area 3 | Percentage of critical damping values (stress levels vs. damping) | No impact, as proposed revision emphasizes a requirement of currently used RG 1.61. | No impact |
| 3.7.2, Area 4 | Soil-structure interaction (identification of uncertainties) | In some cases, additional engineering effort is required, but will remove excessive conservatism leading to lesser design requirements. | 2 staff-weeks |
| 3.7.2, Area 5 | Seismic analysis methods and combination of modal responses (high-frequency modes) | Minor impact on industry, as a one-time modification to current computer programs is required to implement this change. | 2 staff-weeks |

Table 3 (Continued)

| SRP Section and review area | Proposed changes | Industry impact | NRC impact (additional review time) |
|---|---|---|---|
| 3.7.3, Area 6 | Methods of seismic analysis of above-ground tanks | It is estimated that the flexible-tank analysis cost goes up by 25% compared to rigid tank. Since the proposed change is current industry practice, no significant cost impact on the industry is anticipated. | 2 staff-weeks |
| 3.7.3, Area 7 | Category I buried piping, conduit, and tunnels | For new plants, no significant impact is estimated, as the proposed requirement reflects the current industry practice. | No impact |

Note: This table does not contain value/impact assessment of proposed changes that are included as options.

Greater confidence in the seismic adequacy of nuclear power plant structures, systems, and components as the proposed revision reflects new technological advances and incorporates the knowledge gained.

Overall Value/Impact of the Proposed Actions

The value/impact considerations were primarily deterministic and judgmental. The PRA analyses conducted were not conclusive because of limitations in modeling and some anomalies in the predicted releases because of assumptions about containment failure modes. The estimated costs were developed by the staff and by LLNL and its consultants. The proposed action will revise the SRP sections to reflect current state-of-the-art and industry practices. Revision to SRP sections will improve the licensing process by ensuring uniform review, reducing need for additional staff requests for information, eliminating some potential sources of nonconservatisms, and providing options that may lead to reduction in unnecessary conservatisms. Cost estimates indicate that this can be achieved at very low cost.

For the above-ground, vertical tanks, the staff concludes that although the seismic design adequacy is a potential safety issue, the review of tanks is adequately covered by other programs, including the implementation of USI A-46, "Seismic Qualification of Equipment in Operating Plants."

2.1.2 Technical Approach

2.1.2.1 Technical Options

The following options were considered:

(1) Revise SRP Sections 3.7.1, 3.7.2, and 3.7.3 and apply them only to new CP and PDA applications.

(2) Revise SRP Sections 3.7.1, 3.7.2, and 3.7.3 and apply them to all license applicants and backfit them to all holders of operating licenses.

(3) Revise SRP Sections 3.7.1, 3.7.2, and 3.7.3 and initiate plant-specific review of seismic Category I tanks to determine if backfit is necessary.

2.1.2.2 Discussion and Comparison of Technical Options

(1) Adoption of Option 1 (above) would incorporate technical work on the A-40 task into the licensing guidance for future plants. The changes recommended would have little impact on licensees or on the NRC for new plants before the structural design has been initiated except for its use as guidance for seismic re-reviews such as SEP and ISAP (Integrated Safety Assessment Program).

(2) Option 2 (above) would require that all existing plants reanalyze their structures and make changes as necessary to comply with the new requirements. This could potentially have significant cost impact on licensees and applicants.

(3) Option 3 (above) would resolve the safety question of seismic Category I, above-ground tanks, the only item for which potentially significant risk was identified. However, as discussed previously, the integrity of tanks is ensured when reviewed with screening criteria during implementation of USI A-46.

2.1.2.3 Decision on Technical Approach

Option 1 was selected because it satisfies the objective of upgrading the review guidance to reflect current technology and industry practice.

2.1.3 Plan for Implementation

The staff recommends that CP and PDA applicants who docket their applications after the proposed SRP sections are issued be required to design seismic Category I structures, systems, and components to the criteria given in the revised SRP sections.

### 2.1.4 Statutory Considerations

#### 2.1.4.1 NRC Authority

Since the changes are proposed in revision to SRP Sections 3.7.1 through 3.7.3, this action falls within the statutory authority of the NRC. Furthermore, the review of seismic design of Category I structures, systems, and components is within the statutory authority of the NRC to determine safety of nuclear power plants.

#### 2.1.4.2 Need for a National Environmental Policy Act Statement

The proposed changes and potential plant retrofits do not warrant a National Environmental Policy Act statement.

### 2.1.5 Summary

The staff concludes that the proposed actions satisfy the objective of USI A-40 to reflect the current state of the art in seismic design in the licensing process. The assessment of the effect of the proposed changes on plant safety indicates that the changes are warranted and will contribute to a more uniform and consistent licensing process.

## 2.2 Value/Impact Analysis for Proposed Revision to SRP Section 2.5.2

### 2.2.1 The Proposed Action

#### 2.2.1.1 Summary of Issue and Proposed Action

Standard Reviews Plans (SRPs) are prepared for the guidance of NRC staff reviewers who perform safety reviews. The proposed action is to revise SRP Section 2.5.2, "Vibratory Ground Motion," (NUREG-0800) to update and clarify procedures used in the staff's seismology review.

The proposed revision to SRP Section 2.5.2 reflects current staff practice in the review of CP and OL applications. This revision incorporates recent staff positions taken in conjunction with current reviews, ACRS views, and earlier suggestions proposed by the NRC staff and personnel at Lawrence Livermore National Laboratory (NUREG/CR-1161). Most licensees are aware of these positions and proposed requirements. The proposed SRP revision reflects state-of-the-art procedures in assessing seismic hazards. Some of these changes constitute part of the resolution of USI A-40. The staff considered that instead of separating the changes that result from the A-40 study and those changes that are part of a routine SRP revision, it would be better to consider all SRP changes as one action. The objectives of USI A-40 are discussed in Section 2.1.1.1. The LLNL recommendations in NUREG/CR-1161 that affect SRP Section 2.5.2 and have been accepted by the NRC staff are included in the proposed revision to SRP Section 2.5.2.

Although a value/impact statement is needed as part of the Committe to Review Generic Requirements (CRGR) package for A-40, as discussed below, the staff finds that this proposed action will have no impact on licensees.

2.2.1.2 Need for the Proposed Action

In recent years, as the staff has considered pertinent new information and analyses, it has revised its procedures for reviewing the seismic design of nuclear facilities. In recent reviews, pertinent new information has been developed through the time-consuming process of questioning the applicant's Safety Analysis Reports. A revision to the SRP is needed so that future Safety Analysis Reports will include pertinent information at the time of docketing. The major change contained in this revision, site-specific spectra, is discussed next.

The SRP revision suggests that, wherever possible, a site-specific response spectrum (SSRS) should be developed. In recent site reviews (for example, Sequoyah, NUREG-0011; Watts Bar, NUREG-0847) the staff has found site-specific spectra to be a realistic approach to assessing the adequacy of safe-shutdown earthquake (SSE) spectra because this method uses state-of-the-art seismological information and data analysis. The development of an SSRS typically involves the collection of acceleration time-histories from earthquakes of

similar magnitudes (similar to the SSE for the site) recorded at appropriate distances and geologic conditions similar to the site being modeled. One example of an SSRS, developed by LLNL for the NRC, is contained in NUREG/CR-1582, Volume 4 (Appendix A, Section 4.3), "Seismic Hazard Analysis Application of Methodology, Results and Sensitivity Studies." Site-specific response spectra allow for the direct estimation of the response spectrum at all frequencies for specific magnitude, distance, and recording site conditions, rather than the need to develop a reference acceleration (g value) for a site-independent standard spectrum. It has been the staff's position that the appropriate representation of the reponse spectra as derived directly from the real-time-histories is the 84th percentile. The choice of the 84th percentile is based upon (1) past staff practice and licensing decisions, (2) the level used in deriving the RG 1.60 spectral shape, and (3) accounting for uncertainty in predicting response spectra.

2.2.1.3 Value/Impact Assessment of the Proposed Action

There will be no impact on industry because the proposed revision to SRP Section 2.5.2 reflects current staff practice and most licensees are aware of these requirements. One purpose of the SRP is to improve the nuclear power industry's understanding of the staff review process. The proposed revision will reduce delays in the licensing process because information needed for the staff review can be incorporated in the Safety Analysis Reports at the time of docketing instead of later through staff questions and applicant responses. This implementation will not reduce the risk, but will improve the SRP description of current staff practice in licensing.

In some OL reviews, the site-specific spectra have exceeded the SSE and licensees were required to review the structural aspects. However, applying RG 1.60 spectra would, in some cases, have required even more analysis.

Since the seismic design review and acceptance are carried out solely by the NRC staff, no impact on other government agencies is projected. The "value" to the public, if the proposed revision to the SRP is adopted, is greater

confidence in the ground-motion input to seismic design because the proposed revision reflects state-of-the-art practices.

The overall value/impact evaluation of the proposed action indicates that there is no cost impact to industry and no change in public risk.

2.2.2 Technical Approach

The only alternative to revising the SRP is to maintain the current SRP version. This would increase review time in those cases in which information needed for the staff review must be obtained through staff questions and applicant responses.

The proposed revision to SRP Section 2.5.2 reflects the current state of the art and staff practice and is the recommended approach.

2.2.3 Plan for Implementation

The implementation plan is contained in the proposed SRP revision.

2.2.4 Statutory Considerations

2.2.4.1 NRC Authority

Since the changes are proposed in the revision to SRP Section 2.5.2, this action falls within the statutory authority of the NRC. Furthermore, the review of the seismic design of Category I structures, systems, and components is within the statutory authority of the NRC to determine safety adequacy of nuclear power plants.

2.2.4.2 Need for a National Environmental Policy Act Statement

The proposed changes do not warrant a National Environmental Policy Act statement.

### 2.2.5 Summary

The proposed revision to SRP Section 2.5.2 will update and clarify procedures used in the staff seismology review. These revised procedures will decrease licensing costs by decreasing review time. There are no new requirements in the proposed revision because the changes in the proposed revision are current staff practice and are known tc most licensees. Furthermore, there is no change in public risk. The staff recommends issuing the revised SRP section for public comment.

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This report consists of a regulatory analysis for Unresolved Safety Issue (USI) A-40, "Seismic Design Criteria". The regulatory analysis discusses the impact of the proposed changes in the Standard Review Plan (SRP) Sections 2.5.2, 3.7.1, 3.7.2 and 3.7.3 (NUREG-0800).

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