EPRI

RISC-3 Seismic Assessment Guidelines

Preliminary Report

Technical Report

RISC-3 Seismic Assessment Guidelines

1009669

Technical Report, December 2004

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This report describes research sponsored by EPRI.

The report is a corporate document that should be cited in the literature in the following manner:

RISC-3 Seismic Assessment Guidelines, EPRI, Palo Alto, CA: 2004. 1009669.

REPORT SUMMARY

This report provides guidance for establishing reasonable confidence that structures, systems and components (SSCs) of nuclear plants, categorized as RISC-3 under the 10CFR50.69 Risk Informed Safety Categorization Process, will perform their required functions under design basis seismic conditions.

Background

The Nuclear Regulatory Commission (NRC) is amending its regulations to provide an alternative approach for treatment of SSCs for nuclear power reactors using a risk-informed method of categorizing SSCs according to their safety significance. The proposed amendment would permit licensees to remove some of the requirements for "special treatment," i.e., seismic and environmental qualification, from SSCs categorized as RISC-3. This report is concerned with establishing appropriate guidance for the relief from the current regulation that requires seismic qualification testing or analysis of all safety-related SSCs in order to demonstrate that the SSCs are capable of withstanding the design earthquake (Appendix A to 10 CFR Part 100).

Objectives

- To provide guidance to utilities on appropriate methods of meeting the seismic requirements for SSCs that have low safety significance in accordance with the RISC-3 "reasonable confidence" criteria given in 10 CFR 50.69
- To describe alternate treatment methods that will provide reasonable confidence that components categorized as RISC-3 will continue to be able to perform their required functions under design basis seismic conditions.

Approach

The project team defined two cost effective and technically acceptable approaches that provide reasonable confidence in the capability of a RISC-3 component to perform its safety-related function under design basis conditions with respect to seismic effects:

- Use of Seismic Experience (both earthquake and test experience)
- Use of Consensus National Building Code Requirements

Results

The experience-based approach described in this report builds on several earlier RISC-1 seismic approaches such as SQUG Generic Implementation Procedure and the SQUG New and Replacement Equipment that use earthquake and test experience. Core elements based on actual damage and failures are retained from these earlier RISC-1 experience based procedures while other elements have been streamlined in order to reflect their reduced significance for RISC-3 components. The basic elements of requiring anchorage reviews, interaction reviews, and specific caveats associated with failures and damage in earthquakes and tests are maintained in the recommended procedure for RISC-3.

EPRI Perspective

Risk informing the special treatment requirements is intended to focus utility resources on the most safety-significant plant equipment. The implementation of the RISC process is expected to provide significant cost savings without reduction of plant safety. The savings are expected from the reduction of special treatments for applications that are categorized RISC-3. The designation of safety-related, low-safety significant may seem paradoxical. However, the criteria for assigning the term “safety related” to a component were formulated long ago before the advent of dependable risk evaluation methods. This resulted in many components being very conservatively designated as “safety related” when more advanced methods now show that they have little actual safety significance. In the end, the determination that the component is indeed of "low-safety significant" must be the focus. Then one can understand that a reduced level of treatment and reduction of excess conservatisms are satisfactory for RISC-3 applications and see why "reasonable confidence" in the performance of accident functions is acceptable. This report provides guidance on how to establish that SSCs meet their seismic design basis with "reasonable confidence” in accordance with 10CFR50.69.

This guideline is being issued as a preliminary report to allow utilities to perform reviews of the criteria and to conduct trial reviews of its provisions. This guideline will be updated in 2005 based on comments and upgrades from the nuclear industry.

Keywords

Seismic Evaluation
Seismic Qualification
Risk Informed Safety Categorization
RISC-3
Reasonable Confidence
Seismic Design Basis

ACKNOWLEDGMENTS

EPRI wishes to acknowledge the members of the Utility Seismic RISC-3 Task Group for their work on this unique and difficult project:

Divakar Bhargava	Dominion Generation
Biff Bradley	Nuclear Energy Institute
Bruce Henley	TXU
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Vann Stephenson	Progress Energy
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Torrey Yee	Southern California Edison

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1
INTRODUCTION

1.1 Purpose

The Nuclear Regulatory Commission (NRC) is amending its regulations to provide an alternative approach for treatment of structures, systems and components (SSCs) for nuclear power reactors using a risk-informed method of categorizing SSCs according to their safety significance. The proposed amendment would revise requirements with respect to "special treatment," that is, those requirements that provide increased assurances (beyond normal industrial practices) that SSCs perform their design basis functions. This proposed amendment would permit licensees to remove SSCs of low safety significance from the scope of certain identified special treatment requirements.

One of the key special treatment requirements for which licensees desire relief is the regulation that requires seismic qualification testing and specific seismic engineering methods to demonstrate that safety related SSCs are capable of withstanding the design earthquake (Appendix A to Part 100).

The purpose of this document is to provide guidance to utilities on appropriate methods of meeting the seismic requirements in 10 CFR 50.69 for SSCs that have low safety significance in accordance with the RISC-3 criteria. This guideline is being issued as a preliminary report to allow utilities to perform reviews of the criteria and to conduct trial reviews of its provisions. This guideline will be updated in 2005 based on comments and upgrades from the nuclear industry.

1.2 Definition of Key Terms

Reasonable Assurance – A justifiable level of confidence based on objective and measurable facts, actions, or observations which infer adequacy.

Reasonable Confidence – A level of confidence based on facts, actions, knowledge, experience, and/or observations that is adequate for performance of design basis function.

Risk Informed Safety Categorization – The categorization process results in the following four risk informed safety categories:

- RISC-1. SSCs that are safety-related and perform safety-significant functions
- RISC-2. SSCs that are non-safety-related that perform safety-significant functions
- RISC-3. SSCs that are safety-related that perform low safety-significant functions
- RISC-4. SSCs that are non-safety-related that perform low safety-significant functions.

1.3 Acronyms

ACI – American Concrete Institute

AISC – American Institute of Steel Construction

AISI – American Iron and Steel Institute

ANPR – Advanced Notice of Proposed Rulemaking

ANS – American Nuclear Society

ASCE – American Society of Civil Engineers

ASME – American Society of Mechanical Engineers

CEUS – Central and Eastern United States

CDF – Core Damage Frequency

CFR – Code of Federal Regulations

DOE – Department of Energy

G-STERI – Generic Seismic Technical Evaluation of Replacement Items

HSS – High Safety Significant

IBC – International Building Code

ICBO – International Conference of Building Officials

LERF – Large Early Release Frequency

LOCA – Loss of Cooling Water Accident

LSS – Low Safety Significant

NARE – New and Replacement Equipment

NEHRP – National Earthquake Hazards Reduction Program

NEI – Nuclear Energy Institute

NEMA – National Electrical Manufactures Association

OBE – Operating Basis Earthquake

PRA – Probabilistic Risk Assessment

QA – Quality Assurance

RG – Regulatory Guide

RISC – Risk Informed Safety Classification

SECY – Commission Papers

SEI – Structural Engineering Institute

SOC – Statement of Consideration

SQUG – Seismic Qualification Utility Group

SQURTS – Seismic Qualification Reporting and Testing Standardization

SSC – Structure, System or Component

SSE – Safe Shutdown Earthquake

STPNOC – South Texas Project Nuclear Operating Company

TERI – Technical Evaluation of Replacement Items

TR – Technical Report

USGS – United States Geologic Survey

ZPA – Zero Period Acceleration

2
BACKGROUND

2.1 Regulatory History

The NRC has established a set of regulatory requirements for commercial nuclear reactors intended to ensure that a reactor facility does not impose an undue risk to the health and safety of the public. The current NRC regulations are largely based on a "deterministic" approach. Requirements were devised on the basis of a defined and analyzed set of events known as "design basis events." This deterministic approach has employed the use of safety margins, operating experience, accident analysis and a defense-in-depth philosophy.

Currently, the NRC is in the process of issuing a change to regulation 10 CFR 50. The proposed rule change would add a new section, §50.69, which would contain voluntary alternative requirements to certain existing requirements in 10 CFR Parts 21, 50 and Appendix A to Part 100. These changes in the new regulation are primarily with regard to special treatment requirements[1].

2.2 Special Treatment Requirements

One key element of the NRCs defense-in-depth approach is the imposition of special treatment requirements on structures, systems and components (SSCs) that are important to safety to provide a high level of confidence that such SSCs will continue to function during and after the postulated design basis conditions. In regulatory language, this high level of confidence is denoted by the term ***reasonable assurance.*** Special treatment requirements are imposed on nuclear reactor applicants and licensees through a variety of regulations that have been promulgated since the 1960s. The new §50.69 uses the term ***reasonable confidence*** to describe the expected performance of low safety significant safety related SSCs under design basis conditions.

The current deterministic approach towards special treatment of SSCs requires that the licensed facility include and evaluate all safety systems capable of preventing and/or mitigating the consequences of the prescribed Design Basis Events (DBEs) to protect public health and safety.

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[1] Special treatment requirements are current NRC requirements imposed on structures, systems and components that go beyond industry-established (industrial) controls and measures for equipment classified as commercial grade and are intended to provide reasonable assurance that the equipment is capable of meeting its design basis functional requirements under design basis conditions. These additional special treatment requirements include design considerations, qualification, change control, documentation, reporting, maintenance, testing, surveillance and quality assurance requirements.

Those SSCs necessary to defend against the DBEs were defined as "safety-related," and these SSCs were the subject of many specific regulatory requirements designed to ensure that they were of very high quality/reliability and had the capability to perform during and after postulated design basis conditions. Typically, the regulations establish the scope of SSCs that receive special treatment using one of three different terms: "safety-related," "important to safety," or "basic component." The terms "safety-related" and "basic component" are defined in the regulations, while "important to safety" (used principally in the general design criteria of Appendix A to 10 CFR 50) is not explicitly defined.

These prescriptive requirements as to how licensees were to treat SSCs, especially those that are defined as "safety-related," are referred to in the rulemaking as "special treatment requirements." These requirements were developed to provide greater assurance that these SSCs would perform their functions under particular conditions (*e.g., seismic events*), with high quality and reliability, for as long as they are part of the plant. These include particular examination techniques, testing strategies, documentation requirements, personnel qualification requirements, independent oversight, etc.

§50.69 does not replace the existing "safety-related" and "non-safety-related" categorizations. Rather, §50.69 divides these categories into two subcategories based on high or low safety significance. The §50.69 categorizations scheme is depicted in Figure 2-1.

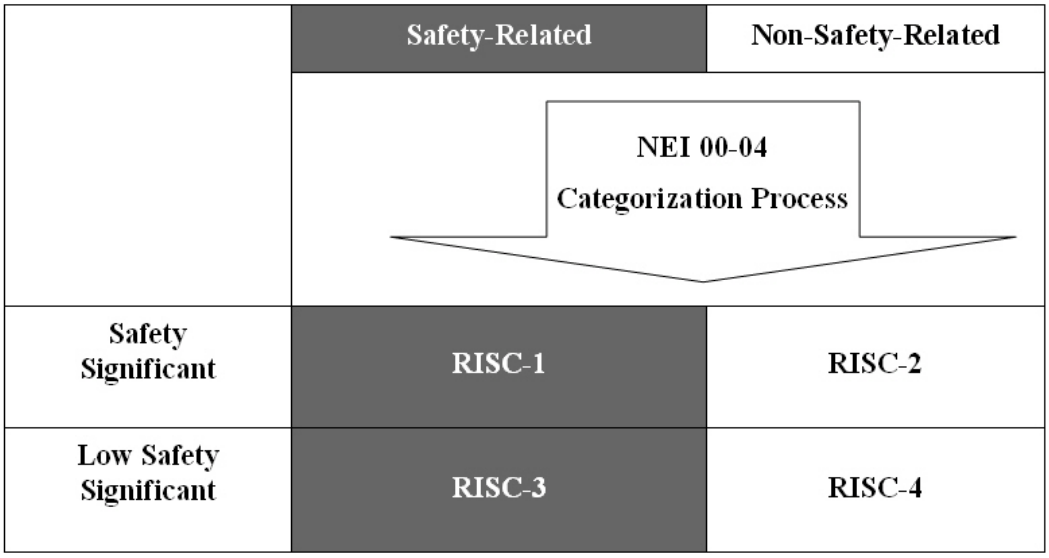

Figure 2-1
Risk Informed Safety Classifications (RISC)

The §50.69 categorization process will verify that some safety-related SSCs are safety significant and will be designated as RISC-1. Others will be found to have low safety-significance and these will be re-categorizied as RISC-3 SSCs. Likewise, some non-safety-related SSCs will be re-categorizied as safety (RISC-2) and others will remain of low or no safety-significance, and be re-categorizied as RISC-4 SSCs. For the purposes of implementing §50.69, "important to safety" SSCs enter into the categorization process as "non-safety-related". Thus, safety-related SSCs can only be categorized as RISC-1 or RISC-3, and non-safety-related SSCs, including the "important to safety" SSCs can only be categorized as RISC-2 or RISC-4.

As discussed above, advances in technology, coupled with operating reactor experience, have suggested that an alternative approach, one that maintains safety while reducing unnecessary regulatory burden, is possible and the use of such an approach could increase regulatory effectiveness. The new approach, embodied in the proposed rules, uses a risk-informed process to evaluate the safety significance of SSCs and establish the appropriate level of treatment requirements for SSCs.

2.3 Nuclear Industry Activity

In March 1996, South Texas Project Nuclear Operating Company (STPNOC) requested that the NRC approve a revised Operations Quality Assurance Program (OQAP) that incorporated the methodology for grading quality assurance (QA) based on PRA insights. The STP graded proposal was an extension of the existing regulatory framework. Specifically, the STP approach continued to use the traditional safety-related categorizations, but allowed for gradation of safety significance within the "safety-related" categorization (consistent with 10 CFR 50 Appendix B) through use of a risk-informed process. The NRC staff approved the proposed revision to the OQAP on November 6, 1997. Subsequent to NRC's approval, STPNOC identified specific implementation difficulties associated with the graded QA program. Despite the reduced QA requirements that applied for a large number of SSCs for which STPNOC judged to be of low safety significance, other regulatory requirements such as seismic and environmental qualification, continued to impose substantial burdens. These special treatment requirements prevented STPNOC from realizing the full potential reduction in unnecessary regulatory burden for SSCs to have little or no safety importance. In an effort to achieve the full benefit of the graded QA program, STPNOC submitted a request to the NRC dated July 13, 1999, asking for an exemption from the scope of numerous special treatment regulations (including 10 CFR 50 Appendix B) for SSCs categorized as low safety-significant. STPNOC's exemption was ultimately approved by the NRC in August 2001.

In parallel to the STPNOC efforts, NEI and EPRI have conducted studies to guide the utilities in cost-effective methods to implement the proposed new §50.69 criteria. There are two segments associated with the implementation of 10 CFR 50.69: 1) the risk-informed categorization of structures, systems and components; and 2) the application of treatment requirements consistent with the safety guidance of the equipment categorized in the first step. NEI 00-04 (10 CFR 50.69 categorization guideline, October 2004) contains detailed guidance on the use of risk insights to define the scope of plant equipment subject to special regulatory treatment provisions.

The application of treatment requirements and controls is a function of the SSC categorization. The existing treatment provisions for RISC-1 and RISC-2 SSCs are maintained or enhanced to provide "reasonable assurance" that the safety-significant functions, identified in the §50.69 process will be satisfied. RISC-3 and RISC-4 SSCs are governed by the new treatment requirements, as described in 10 CFR 50.69. The treatment requirements for RISC-3 SSCs with respect to seismic and environmental qualification are addressed in a very broad manner within §50.69 and licensees are expected to develop more detailed application programs to meet these broad requirements. The purpose of this document is to provide a set of assessment guidelines for seismic consideration of RISC-3 components.

2.4 Design Basis Determination for RISC-3

For RISC-3 SSCs, 10 CFR 50.69 would impose requirements which are intended to maintain their design basis capability. Although individually RISC-3 SSCs are not significant contributors to plant safety, they do perform functions necessary to respond to certain design basis events of the plant safety and they do perform functions necessary to respond to certain design basis events of the facility. Maintenance of RISC-3 design basis functionality is important to ensuring that defense-in-depth and safety margins are maintained. Thus, a newly designed or procured replacement RISC-3 item must be capable of meeting its design basis requirements, even though the special treatment requirements that previously existed are no longer required.

10 CFR 50, "Domestic Licensing of Production and Utilization Facilities" Section 50.2 contains the high level definition of the term "design bases." The NRC staff and the nuclear utility industry agree on this high level definition but have disagreed in the past as to the more detailed definition of the "design bases" term and its specific requirements for implementation. As a result, NEI has developed a guideline for design bases determination, NEI 97-04 "Design Basis Program Guidelines." NEI 97-04 is an update of the earlier NUMARK 90-12, gives specific examples of design basis information and directly addresses the reportability of conditions outside of the design basis of the plant.

The NRC endorsed Appendix B of the NEI 97-04 report (with exceptions) in Draft Regulatory Guide DG-1093. NEI revised parts of Appendix B in November of 2000 to address the NRC and public comments. The NRC then issued Regulatory Guide 1.186 "Guidance and Examples for Identifying 10 CFR 50.2 Design Bases" in December 2000. They give specific endorsement of Appendix B within RG 1.186:

> "Appendix B, *Guidelines and Examples for Identifying* 10 CFR 50.2 Design Bases, (dated November 27, 2004) to NEI 97-04 provides guidance and examples that are acceptable to the staff for providing a clearer understanding of what constitutes design bases information."

Thus, in order to demonstrate that these recommended seismic RISC-3 methods will maintain the seismic design bases the guidance provided in Appendix B to NEI 97-04 will be used to define the appropriate seismic design basis requirements.

NEI 97-04 Appendix B

NEI developed guidelines within NEI 97-04 for determining the boundaries between "design basis," "licensing basis," "supporting design information" and "UFSAR information." The basic guideline resulting categorization can best be described in Figure 2-2 below, which depicts the design basis commitments to be a subset of the information within the UFSAR and separate from supporting design information. NEI 97-04 Appendix B gives specific guidance in clarifying the distinction between the design bases and the supporting design information.

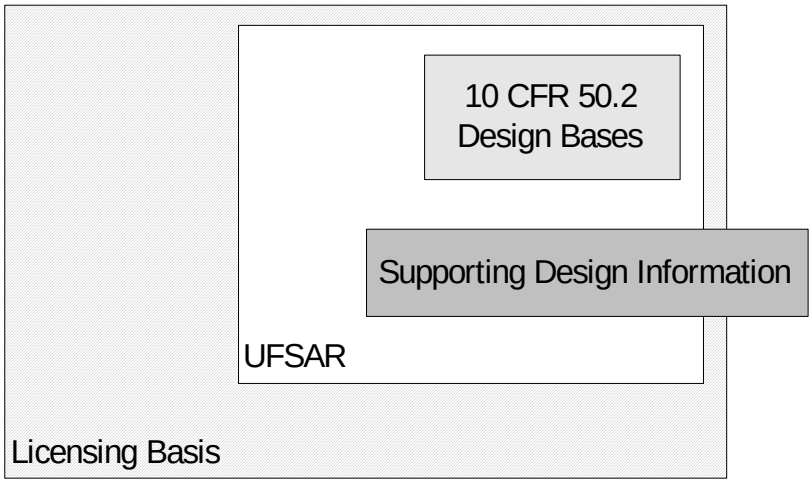

Figure 2-2
Design Basis Determination

Appendix B defines the fundamental design basis functional requirement to be:

> "Structures, systems, and components important to safety shall be designed to withstand the effects of earthquakes without loss of capability to perform their safety related function."

In this regard, they define example controlling parameters for both the Design Basis and for Supporting Design Information:

Seismic Design Basis

- SSCs shall be analyzed and designed to withstand the effects of an OBE with a PGA of X and an SSE with a PGA of Y.
- Category II SSCs installed in Seismic Category I structures whose failure could result in a loss of required safety function of Category I SSCs are either designed to maintain their structural integrity during the SSE or are shielded by a barrier or adequate distance.

Seismic Supporting Design Information

- Seismic design response spectra are in conformance with NRC Regulatory Guide 1.60.
- Seismic Damping values are consistent with RG 1.61.
- For Seismic analysis of ASME Boiler and Pressure Vessel Code Section III, Division 1 Code Class 1, 2 and 3 piping systems, ASME Code Case N-411 damping values may be used.
- Category II structures are designed using the UBC Code, Version XXX.

Thus, the proposed methodology for seismic RISC-3 evaluations will incorporate an evaluation to the specific earthquake peak ground motion definition at the site being reviewed as well as a specific evaluation to ensure that seismic interaction (Category II/Category I) is properly addressed for each RISC-3 component. The seismic RISC-3 criteria specifically addresses the SSE earthquake only. Since the OBE has both a lower PGA and peak spectral acceleration, it will not be controlling in the seismic evaluation. This is consistent with the fact that the OBE was not required to be addressed as part of the USI A-46 resolution. In addition, earthquake

experience has documented many instances wherein large earthquakes are followed by multiple aftershocks affecting the same equipment. Damage investigations for these multiple aftershocks has not been shown to produce new failures for the classes of equipment addressed by SQUG in the GIP and provides reasonable confidence that the OBE will not affect the seismic capacity of RISC-3 SSCs.

2.5 Seismic Evaluations in the Engineering Change Process

A power plant is a complex functioning dynamic process which relies on interacting systems of mechanical and electrical equipment. Components of these systems require maintenance, wear out and require replacement, or need to be upgraded to reflect new technology that improves both functional reliability and plant safety. A nuclear power plant, however, is licensed in it's original configuration and those components which are safety related (Category I) must have configuration control in order to satisfy the licensing commitments. If maintenance or engineering activity identifies the need for a replacement or change in the existing configuration of a controlled item, then the need for an "Engineering Change" is established. All engineering changes must consider a seismic evaluation since a seismic design event affects the entire plant site. Figure 2-3 shows how seismic evaluations should be considered in the Engineering Change process. The first three types of Engineering Change do not require any seismic evaluations, however, replacement items may be evaluated by STERI if the item is equivalent and as a design change if it isn't equivalent.

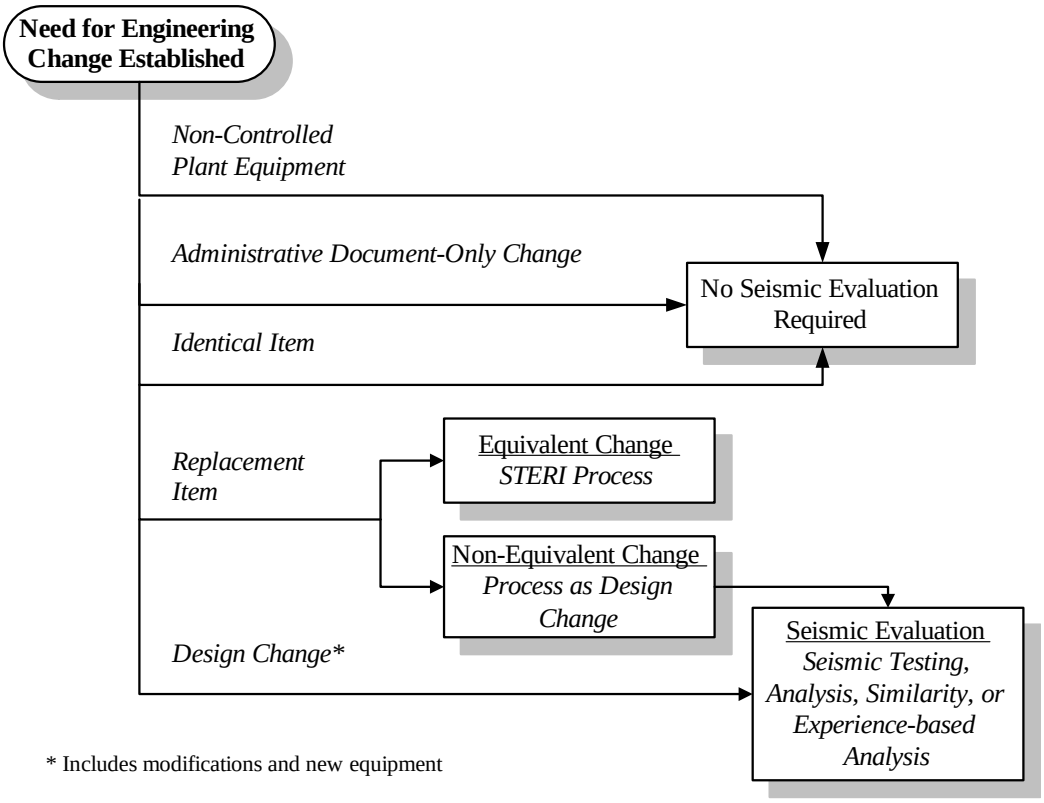

Figure 2-3
Engineering Change Seismic Evaluations

Figure 2-4 shows the seismic evaluation methods in greater detail as well as the information that needs to be communicated and coordinated with the Procurement Engineering group. In general, identical or equivalent alternate replacements can be completely handled by procurement engineering as long as adequate guidance criteria is available to ensure that a procured and installed part does not affect the prior qualification of the host equipment. Design change, however, requires the consideration of qualification methods (test or analysis) in order to demonstrate reasonable assurance of seismic function.

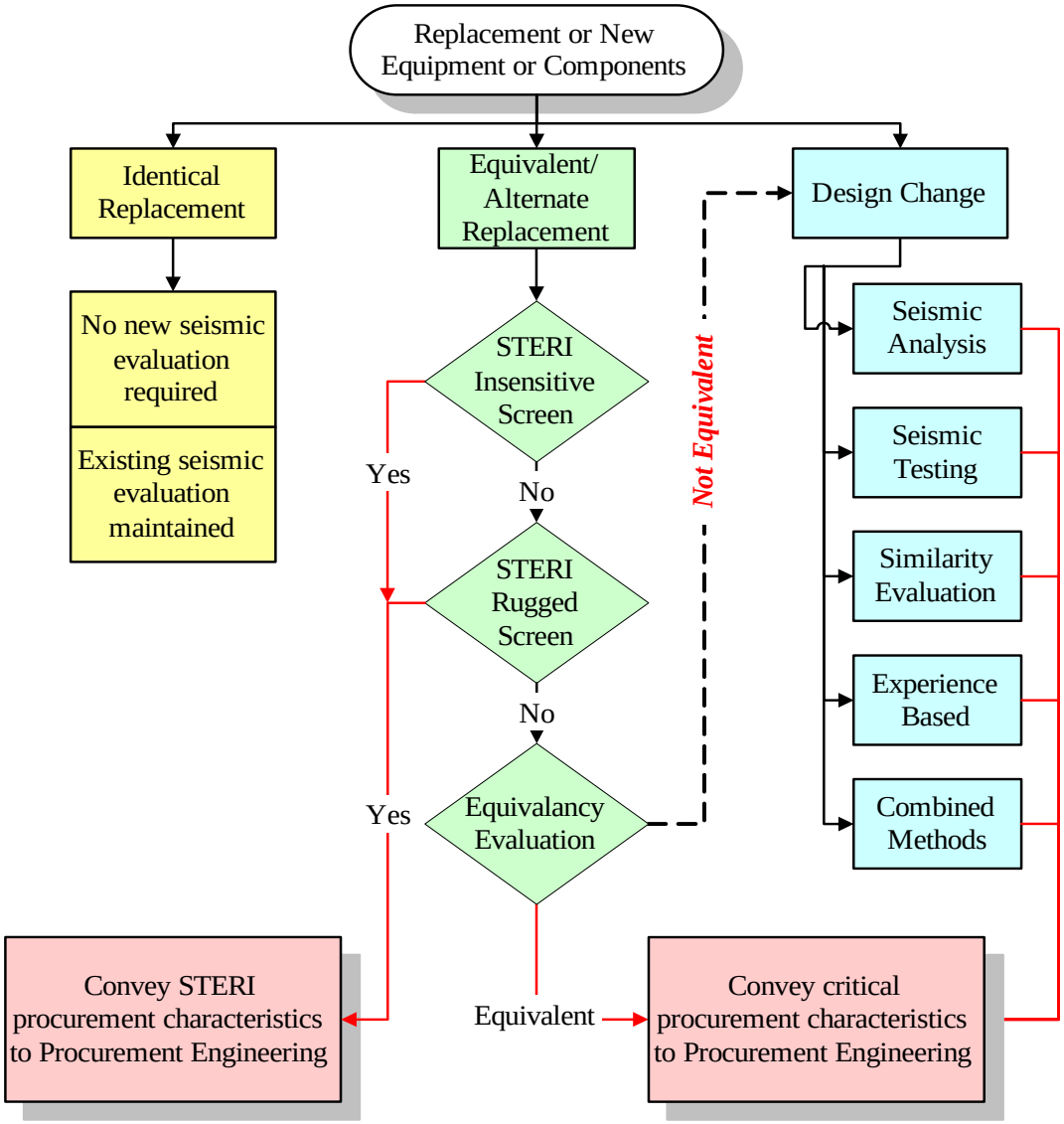

Figure 2-4
Seismic Evaluation Methods

3
ESTABLISHING REASONABLE CONFIDENCE

3.1 Terminology Used in 10 CFR 50.69

The term "reasonable confidence" is used in Section III of 10 CFR 50.69 a number of times as noted below (emphasis added):

> "Effective implementation of the treatment requirements provides **reasonable confidence** in the capability of RISC-3 SSCs to perform their safety function under normal and design basis conditions. This level of confidence is both less than that associated with RISC–1 SSCs, which are subject to all special treatment requirements, and consistent with their low safety significance."
>
> "Maintenance of RISC-3 design basis functionality is important to ensuring that defense-in-depth and safety margins are maintained. As a result, § 50.69(d)(2) would require licensees or applicants to have processes in place that provide **reasonable confidence** in the capability of RISC-3 SSCs to perform their safety- related functions under design basis conditions throughout the service life."
>
> "The performance of candidate RISC-3 SSCs should not be significantly degraded by the removal of special treatment. This is because the licensee is required to implement processes that provide **reasonable confidence** that SSCs remain functional, that is, remain capable of performing their function with a reliability that is not significantly degraded to such an extent that there will be a significant number of failures that can lead to unacceptable increases in CDF or LERF."

Although the terminology is used extensively throughout the regulation, there is no definition provided in §50.69 nor does it describe approaches that will meet this objective. Omission of a definition or clarification leaves the term subjective and open to interpretation by each licensee opting to implement the regulation.

Therefore, the following guidance is provided to assist licensees opting to implement §50.69 in terms of more clearly understanding the concept of reasonable confidence.

3.2 Defining Reasonable Confidence

For the purposes of this report, the term "reasonable confidence" is used to denote the appropriate and qualitative level necessary for RISC-3 equipment performance. This is consistent with its use in 10 CFR 50.69. For the purposes of this report, reasonable confidence is defined as follows:

> Reasonable confidence – A level of confidence based on facts, actions, knowledge, experience, and/or observations that is adequate for performance of design basis function.

Note that the term "actions" may constitute verifications, calculations, tests, or comparison activities.

Also for the purposes of this report, the term "reasonable assurance" is used to denote the appropriate and qualitative level necessary for safety-related, high safety-significant (RISC-1) equipment performance. This is consistent with its use in 10 CFR 50, Appendix B, ANSI N45.2 implementing standards.

3.3 Reasonable Confidence for Seismic

The key role this report fulfills is to define cost effective and technically acceptable approaches that provide *reasonable confidence* in the capability of a RISC-3 component to perform its safety-related function under design basis conditions with respect to seismic effects. Given that "reasonable assurance" is associated with high confidence then "reasonable confidence" is somewhere within the range between moderate and high confidence. This report provides recommendations for criteria that achieve reasonable confidence on the collective judgments of a team of experienced seismic practitioners with many years of experience in studying the effects of equipment performance in dynamic load environments. This report does not define the only way or ways in which reasonable confidence can be established. Alternate, equally effective approaches may exist and should be used when appropriate.

3.3.1 Reasonable Confidence for Experience-Based Evaluations

In establishing a level of reasonable confidence in the performance of RISC-3 components subjected to seismic loads, techniques used in conventional nuclear plant design basis type seismic engineering design could be a starting point. These seismic design and analysis practices leave little room for experience, uncertainties, summary levels of documentation, and engineering judgment, and favor detailed tests or analyses with multiple levels of safety margins. Such practices are appropriate for safety-related components that are safety significant (i.e., components with a function whose degradation or loss could result in a significant adverse affect on defense-in-depth, safety margin or risk.). However, they can be excessive (and not cost effective) for components that have low safety significance (RISC-3), whose degradation or failure do not significantly affect defense-in-depth, safety margin and risk. Accordingly, the industry has chosen to utilize the significant database of very severe seismic tests/earthquakes as the underlying basis for demonstrating that the component integrity and function is assured. The data from severe earthquakes in California, Japan, Taiwan, Turkey and other areas of very high seismicity have been utilized in coming up with an appropriate criteria for RISC-3 components. In addition, data from shake table tests at high levels have been studied to ensure that all critical failure modes have been considered when setting the criteria. Because the component withstood the very severe exposure existing within these tests and earthquakes, there is a reasonable level of confidence that the RISC-3 device will function at any time in its qualified life through a design basis seismic event. Several RISC-1 approaches have been developed in the past which are also based on the use of earthquake and test experience (e.g., the SQUG Generic Implementation Procedure and the SQUG New and Replacement Equipment procedure). The intent of this RISC-3 criteria is to include the core elements of these earlier RISC-1 experience-based procedures which were based on actual damage and failures, but to streamline the process in terms of requirements that originated based on other considerations.

The basic elements of requiring anchorage reviews, interaction reviews and specific caveats associated with failures and damage in earthquakes and tests will be maintained in the recommended procedure for RISC-3 as described in the subsequent sections of this guideline.

3.3.2 Reasonable Confidence for ASCE 7-02 Based Evaluations

Evaluation methods complying with the ASCE Standard 7-02 represent an approach that meets the RISC-3 requirements for reasonable confidence of seismic adequacy based on the following:

- ASCE 7 is a Consensus National Standard which followed a formal development, review and approval process involving a wide range of industry seismic experts.
- ASCE 7 is the most recent structural/seismic standard to be published and was judged to contain the most appropriate state-of-the-art methodologies with respect to SSC seismic design and verification. The design level seismic demand is set at a reduced level which provides a reasonable confidence that the mechanical or electrical equipment will perform its function for an event, larger than the design event, that is considered to be the maximum credible seismic motion. Current nuclear design (RISC-1) uses the maximum credible seismic motion as the basis of design in order to achieve reasonable assurance of function.
- ASCE 7 is recommended by the International Building Code for seismic assessment of SSCs. It should be noted that the 2003 International Building Code (IBC) has replaced the three major US building codes that have been used in the past (UBC, BOCA and the Standard Building Code). Unlike the preceding IBC versions, the 2003 IBC has referenced ASCE 7-02 with respect to the detailed seismic design requirements for equipment and nonstructural components. These seismic requirements are graded depending upon the criticality of the component to life safety or essential facility operation.
- ASCE 7 contains seismic criteria to assure functionality of critical equipment following the seismic event (The ASCE criteria used for RISC-3 has also been enhanced with relay review criteria to ensure functionality during earthquakes also).

3.3.3 Reasonable Confidence through the Procurement Process for Replacement Parts

The procurement process used for replacement parts of RISC-3 components helps establish reasonable confidence in the seismic capacity. Procurement documents will not specify "nuclear safety-related" or be controlled by a 10 CFR 50, Appendix B quality assurance program. However, they should describe the general seismic conditions for the RISC-3 component. Stating the seismic conditions in the procurement document allows the vendor to recognize and take exception to conditions that are beyond the device's capabilities. In those cases, the licensee is made aware when additional assessment is necessary or that an alternate device should be sought.

A working relationship with a vendor and/or discussions of seismic needs with the vendor prior to procurement will help establish reasonable confidence in the performance during and following a seismic event. Vendors/manufacturers may have additional information beyond that developed under a nuclear quality assurance program that can provide a basis or partial basis for withstanding a seismic event. Such information may include operating experience information, analyses, shake table test results or actual earthquake experience data.

Identical and alternate components will often be procured from vendors with experience serving the nuclear industry. Such vendors will likely be able to answer questions related to the seismic vulnerabilities (or lack thereof) for their devices and provide guidance on appropriate material or configuration considerations for licensees to be able to assess the suitability of devices for RISC-3 seismic service.

4
SEISMIC EVALUATION APPROACH FOR RISC-3 SSCS

4.1 Recommended Approach for Seismic Evaluation of RISC-3 SSCs

As stated in Chapter 2 of this report, the NRC proposed amendment to 10 CFR 50 will add a new section 50.69 on the risk-informed categorization and treatment of SSCs at nuclear power plants. However, licensed operating plants are currently subject to the deterministic seismic design requirements set forth in Appendix A to 10 CFR 100. Safety-related SSCs are required to be designed to withstand the SSE and OBE motion levels as established for each reactor site as part of the plant-specific licensing criteria. The specific wording of the current rule requires that the function of safety-related SSCs be demonstrated by either a *suitable dynamic analysis or suitable qualification test.* This level of assurance provided by testing or analysis is considered to be a special treatment requirement which is to provide a high confidence (i.e., reasonable assurance) of functional performance. The proposed rule change, Section 50.69 of 10 CFR 50, would remove RISC-3 SSCs at operating power reactors from the special treatment requirements of Appendix A to 10 CFR 100. However, 50.69 maintains the requirements that RISC-3 SSCs must demonstrate functionality for both the SSE and OBE motion levels, but at a reduced level of assurance that provides ***reasonable confidence of functional performance***. Licensees are required to provide "reasonable confidence in the capability of RISC-3 SSCs to perform their safety-related functions including design requirements for environmental conditions and seismic conditions (design load combinations of normal and accident conditions with earthquake motions)."

With these requirements in mind, EPRI has developed a set of acceptable approaches to demonstrate that RISC-3 SSCs will meet (with reasonable confidence) the appropriate seismic requirements. The recommended approaches for meeting the RISC-3 seismic requirements are separated into those affecting design changes and new equipment and those affecting replacement equipment and parts. Figure 4-1 contains a flow chart description of the overall logic for seismic RISC-3 approaches.

Chapter 5 of this report contains descriptions of the approaches for modifications requiring design changes or new equipment and Chapter 6 contains descriptions for replacement parts and equipment. Each of the methods described in Chapters 5 and 6 has different strengths/efficiencies and utilities may determine that it is most cost effective to use either method independently or a combination of these methods when demonstrating the seismic adequacy of RISC-3 components. In addition, alternate methods beyond these types could also be developed which would meet the requirements outlined in Section 2 to demonstrate seismic adequacy with reasonable confidence.

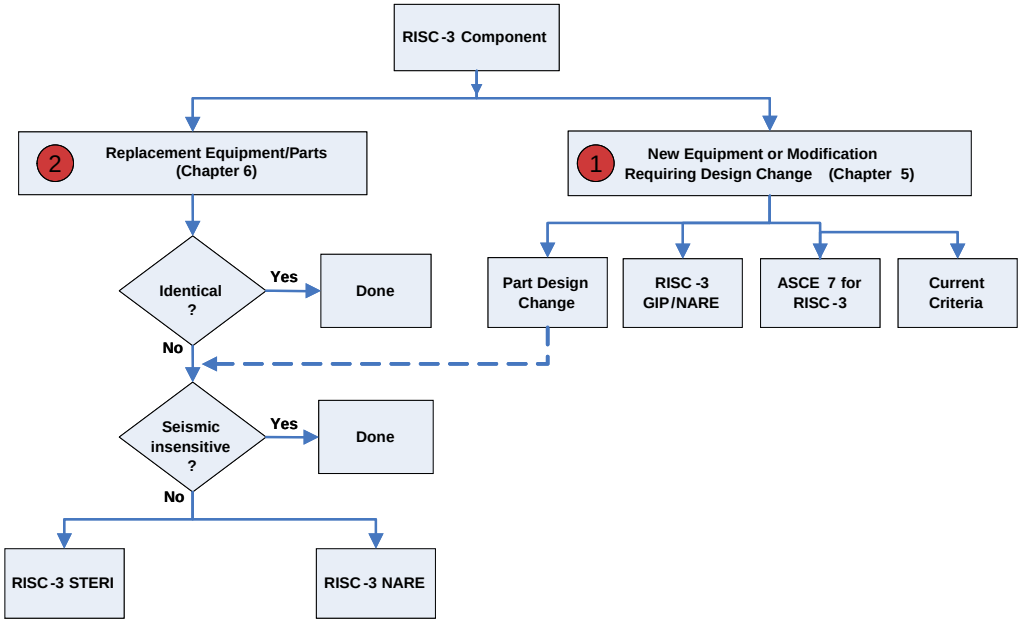

Figure 4-1
Seismic RISC-3 Assessment Flow Chart

5
SEISMIC RISC-3 FOR NEW EQUIPMENT OR MODIFICATIONS REQUIRING DESIGN CHANGE

5.1 Recommended Approach for New or Modified RISC-3 SSCs

When a RISC-3 equipment item requires a modification that, under established plant procedures, must be considered as a design change[2], alternate approaches can be considered to provide reasonable confidence that the modified RISC-3 equipment is seismically adequate. In addition, the replacement of RISC-3 equipment with a new item or the addition of new equipment items, can also be considered as a change in the plant design basis depending on the equipment system involved. The alternate approaches for demonstration of reasonable confidence in the capability of RISC-3 SSCs to perform their safety function under normal and design basis conditions are:

- Use of Seismic Experience (both earthquake and test experience)
- Use of Consensus National Building Code Requirements (ASCE 7)
- Use of Current Criteria (existing plant seismic qualification procedures)
- Use of Replacement Part Criteria (for small additions/modifications to existing RISC-3 items)

These approaches are shown in Figure 5-1, which outlines the logic and process for consideration of seismic treatment of new or modified RISC-3 SSCs.

[2] Each plant has certain requirements and criteria for determining if a modification must be considered as a change in the plant design basis.

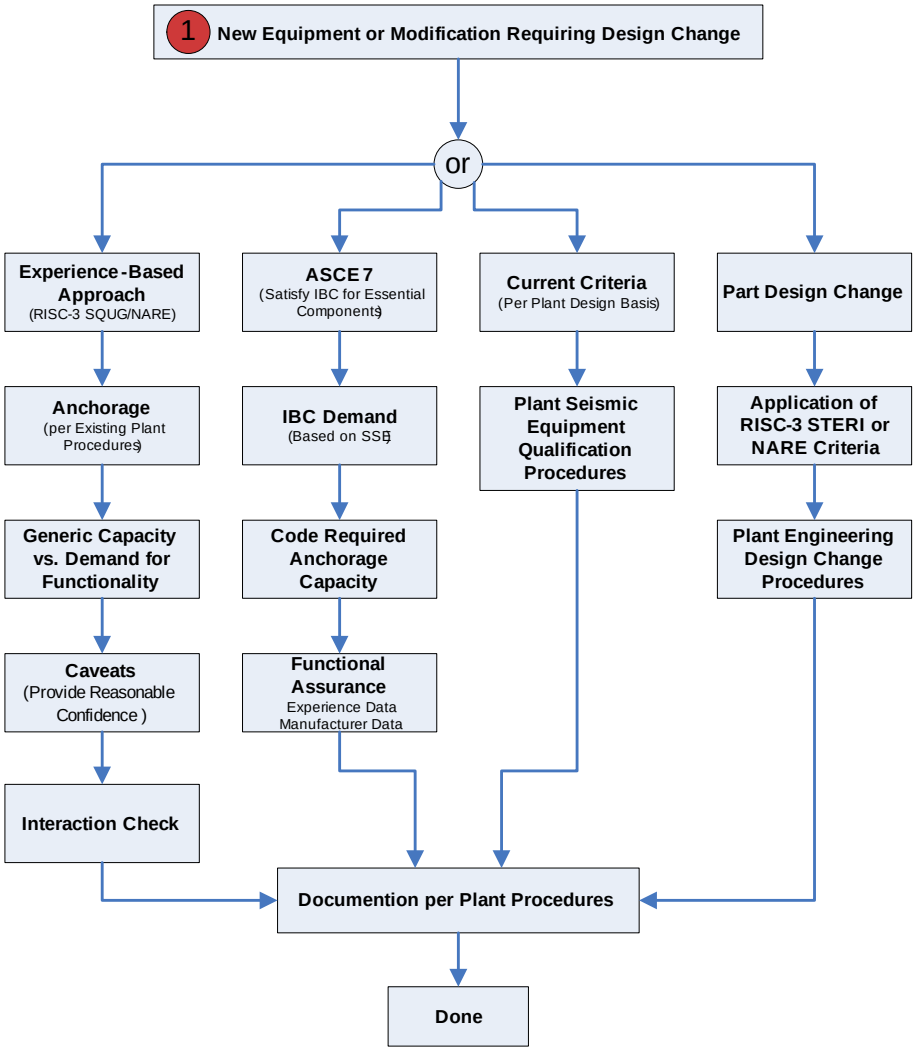

Figure 5-1
RISC-3 Modification or New Equipment Process

5.2 Seismic Experience-Based Approach for RISC-3 Items

During the 1980s, the Unresolved Safety Issue A-46 program was undertaken by nuclear licensees and the NRC, which addressed the lack of explicit seismic qualification of SSCs in older vintage nuclear power plants consistent with that performed for newer nuclear plants. The resolution of the USI A-46 issue was accomplished by demonstrating that the equipment found in nuclear plants is the same as that used in fossil fuel power plants and heavy industrial facilities that had been subjected to strong ground motion. A considerable amount of research on the actual effects of earthquakes, shake table testing of equipment, seismic testing of relays to establish capacities, anchorage criteria and failure modes, etc. was conducted over the last 20 years in support of the A-46 resolution. A partial list of some of that research is summarized in the list below:

- EPRI Report NP-7149-D *Summary of the Seismic Adequacy of Twenty Classes of Equipment Required for the Safe Shutdown of Nuclear Plants*, March 1991.
- *Investigation of the 1999 Kocaeli Turkey Earthquake: Effects on Power and Industrial Facilities,* by EQE International, September 2001. EPRI Technical Report.
- *The Gujarat, India Earthquake of January 26, 2001: Effects on Selected Power and Industrial Facilities* by ABS Consulting, December 2003. EPRI Technical Report.
- EQE Engineering Report "The January 17, 1995 Kobe Earthquake: An EQE Summary Report" April 1995.
- *Guideline for the Seismic Technical Evaluation of Replacement Items for Nuclear Power Plants*, February 1993. EPRI Report NP-7484.
- *Generic Seismic Technical Evaluations of Replacement Items for Nuclear Power Plants*, 19XX. EPRI Report TR-104871.
- Advance Light Water Reactor (ALWR) First-of-a-Kind Engineering Project on Equipment Seismic Qualification, February 1996.
- *Generic Seismic Technical Evaluations of Replacement Items for Nuclear Power Plants - Item-Specific Evaluations*, March 1996 and Supplement 1 (SU-105849). EPRI Report TR 105849.
- NUREG/CR-6464 An Evaluation of Methodology of Equipment, Cable Trays, and Ducts in ALWR Plants by Use of Experience Data, July 1997.
- *Critical Characteristics for Acceptance of Seismically Sensitive Items (CCASSI)*, September 2000. EPRI Report TR-112579.
- Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant Equipment, Rev. 3A, December 2001.
- Department of Energy "Seismic Evaluation Procedure for Equipment in U.S. Department of Energy Facilities," March 1977.
- *Seismic Evaluation Guidelines for HVAC Duct and Damper Systems*, April 2003. EPRI Report 1007896.
- SQURTS Web site: http://www.epri.com/squrts/.
- Electronic SQUG Database Web Site: http://www.epriq.com/esqug/.
- *Generic Seismic Ruggedness of Power Plant Equipment in Nuclear Power Plants*, ANCO Engineers, February 1991. EPRI Report NP-5223.
- *Seismic Verification of Nuclear Plant Equipment Anchorage* URS Corporation, June 1991. EPRI Report NP-5228.
- *Seismic Ruggedness of Relays*, ANCO Engineers, February 1991. EPRI Report NP-7174.
- *The Performance of Raceway Systems in Strong Motion Earthquakes*, EQE Inc., March 1991. EPRI Report NP-7150.

The fundamental conclusion that results from this compendium of recent research is that power plant equipment can be considered as generically rugged with respect to seismic loading provided it meets a limited set of criteria. Both the Senior Seismic Review and Advisory Panel (SSRAP) and the NRC (NUREG 1030 and NUREG 1211) came to the following conclusions with respect to power plant equipment performance in large earthquakes:

1. Equipment installed in nuclear power plants is generally similar to and at least as rugged as that installed in conventional power plants that have undergone high level earthquakes.
2. This equipment has an inherent seismic ruggedness and a demonstrated capability to withstand significant seismic motion without structural damage as long as adequate engineered anchorage is present.
3. Functionality after the earthquake has been demonstrated based on earthquake experience and, in addition, no loss of functionality during earthquake motion has been observed. This conclusion is also supported by a large body of test experience data.
4. Relay chatter during the earthquake has not been ruled out. Once the relay chatter issue is addressed, the functionality of the equipment during the earthquake has been demonstrated.
5. Certain characteristics have been shown to be vulnerable to seismic shaking (brittle materials, seismic interactions, etc.).

A RISC-3 evaluation criteria built around these fundamental conclusions from this voluminous research should provide *reasonable confidence* in the capability of RISC-3 SSCs to perform their safety function under normal and seismic design basis conditions.

5.2.1 Experience-Based Criteria for Seismic RISC-3

The experience based criteria recommended by EPRI for establishing reasonable confidence for the seismic adequacy of RISC-3 components is based on RISC-1 criteria and consist of 1) a demonstration that the seismic capacity of the SSC exceeds the seismic demand imposed on the SSC and 2) the satisfactory completion of certain engineering evaluations. These engineering evaluations focus on three key areas which are depicted in Figure 5-2.

- Capacity to Demand Comparison
- Engineering Evaluations
  - Anchorage Evaluation and Load Path
  - Interaction Evaluation
  - Critical Features Review Based on Observed Earthquake Damage

While these basic steps are included within experience based methods for both RISC-1 and RISC-3 components, several differences in the specific implementation approaches will be described in the subsequent sections of this report.

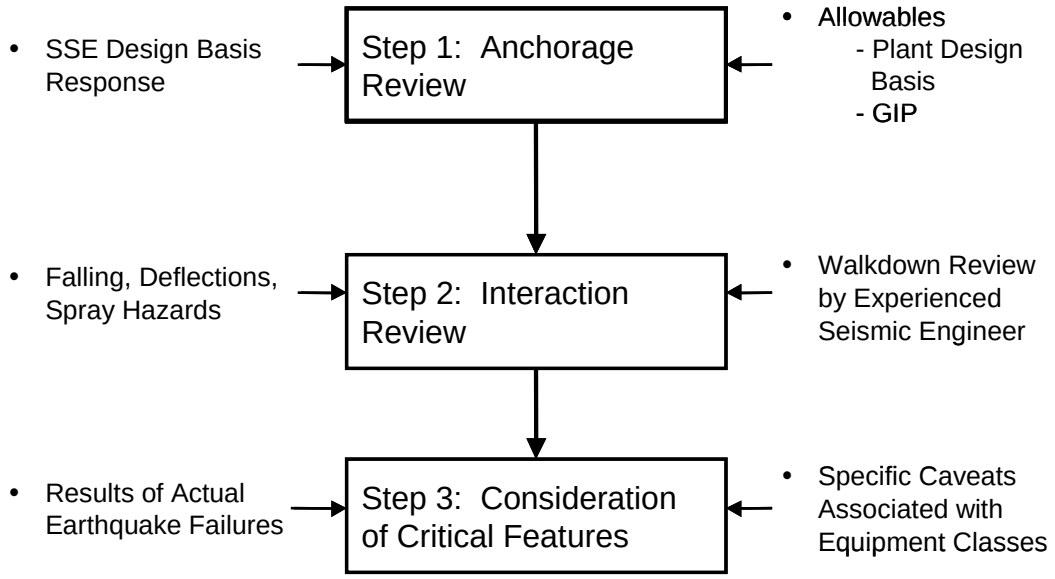

Figure 5-2
Seismic Experience Based RISC-3 Engineering Evaluations

5.2.2 Assessment of Equipment Function and Relay Performance

Research from the actual earthquake experience indicated that, with certain restrictions/caveats, the general classes of mechanical and electrical equipment had demonstrated sufficient ruggedness to render an explicit testing/analysis seismic qualification unnecessary. A peer review panel (SSRAP) was jointly appointed by the NRC and the industry to review the experience based methodology and the USI A-46 issue resolution. SSRAP concluded that up to a motion level denoted as the Reference Spectrum, with the exception of relay chatter, the functionality of equipment both *during* and *after* strong ground shaking had been demonstrated. Here the term "relay" denoted a contact type device such as a control or protective relay, motor starter, contactor, switch, etc. The direct observation of no system anomalies during an earthquake has been relied upon by SSRAP to indicate that equipment function was not impaired during the period of strong shaking. A review of relays (including contractors, switches, etc.) has been included in RISC-3 evaluations in recognition of SSRAP's judgment that the earthquake experience data does not necessarily demonstrate that relays performed their intended function during the earthquake. Three references, (EPRI, 1990), (Hardy, 1990), and (EPRI, 1991a) contain recommended approaches for evaluating relay seismic capacities in addition to the obvious option of using current plant design basis seismic qualification approaches.

5.2.3 Capacity to Demand Evaluation

The GIP Reference Spectrum has been developed to represent a documented level of seismic motion for which a substantial number of equipment systems are seismically adequate. It represents a generic input level which is at least a factor of two less than the actual mean seismic capacity of equipment components. The GIP Reference Spectrum is a high confidence measure of capacity and when used in accordance with the GIP criteria, is an acceptable capacity for RISC-1 SSCs at USI A-46 plants.

The seismic demand on building mounted equipment systems within each plant is represented by floor response spectra, which have been analytically generated using each plant's design basis SSE. These floor spectra have been normally developed with very conservative assumptions that yield demand levels that greatly exceed any measured levels of actual building motion observed in actual earthquakes. Thus, the comparison of conservative demand (high) with conservative (low) capacity, is the current basis of demonstrating, with high confidence, the seismic adequacy of RISC-1 SSCs.

For RISC-3 SSCs, it is recommended that the demand levels used to verify functional performance be similar to those specified by national building code standards for the design of important (essential) facilities. In order to maintain the plant design basis, the plant SSE should be utilized instead of the Maximum Considered Earthquake (MCE) specified within the ASCE 7 standard. Section 5.3 and Appendix A provide an evaluation of the ASCE 7 approach, which concludes that a generic floor spectra can be generated which bounds the expected demand for all plant structure elevations. This generic demand level can then be directly compared with the GIP Reference Spectrum. This comparison of generic demand with generic capacity shows that functional capacity exceeds demand for all plants in CEUS with SSEs characterized by ZPA levels less than 0.22 g. Thus, reasonable confidence of equipment functional seismic adequacy can be provided on a generic basis, as long as the engineering evaluation criteria are satisfied.

5.2.4 Engineering Evaluations

5.2.4.1 Anchorage Evaluation

The research investigations of actual earthquake damage to power plants and heavy industrial facilities concluded that the presence of an adequate load path to engineered anchorage was the primary requirement that assured the functionality of equipment during and after an earthquake. Existing plant design criteria for equipment anchorage provides a high level of confidence that the conservative demand of existing plant design floor spectra can be met for RISC-1 applications. There appears to be little cost benefit for designing equipment anchorage for the generic demand levels recommended for RISC-3 functional evaluations. Thus, it is recommended that anchorage design of RISC-3 items utilize the demand levels provided by the plant floor spectra and the plant anchorage design procedures currently specified for design of RISC-1 equipment anchorages.

5.2.4.2 Interaction Evaluation

The research investigations of actual earthquake damage to power plants and heavy industrial facilities also concluded that most non-anchorage damage to equipment was caused by seismic interaction of the equipment with other systems. This evaluation is best conducted by walkdown observation of the spatial proximity of adjacent systems to the location of the equipment item being evaluated. In some cases, the adjacent systems will require modification to preclude any seismic interactions. Some plants refer to these types of evaluations as II/I evaluations.

5.2.4.3 Considerations Based on Critical Features

The research investigations of actual earthquake damage to power plants and heavy industrial facilities identified certain issues associated with each class of equipment, which if addressed on a case-specific basis, provided additional assurance of equipment function. These concerns were addressed by caveats, which if satisfied, assured seismic adequacy. Given the primary evaluations for anchorage design and seismic interactions have been conducted, the review of the applicable caveats is the final evaluation step. For example, relays and other associated electrical/mechanical contact devices were identified as caveats and require separate evaluation. Appendix B provides a description of Critical Caveats based on Actual Damage/Failures from the SQUP GIP along with a review of the intent of each caveat. Only those caveats necessary for reasonable confidence of equipment function will be considered applicable to RISC-3 equipment design.

5.3 ASCE 7-02 Approach for RISC-3 Items

This approach fundamentally follows the methodology for seismic design/evaluation of SSCs documented within ASCE Standard 7-02. This standard is titled "Minimum Design Loads for Buildings and Other Structures" and is a consensus standard jointly developed by the American Society of Civil Engineers (ASCE) and the Structural Engineering Institute (SEI). This document is the basis for the International Building Code 2003 (IBC 2003) which is a national building code that specifically addresses the seismic design of equipment systems within essential facilities with the intent of providing a reasonable confidence of functional performance following an earthquake. The approach is focused on providing anchorage and additional consideration of critical features of selected SSCs.

The developers of ASCE 7 were cognizant of the experience-based methods developed by SQUG in support of resolving USI A-46. They included general requirements and restrictions for SSCs deemed to be critical for functionality following the earthquake. The suppliers of the equipment are responsible for providing the reasonable confidence of equipment function following an earthquake using analysis, test, or seismic experience data.

The use of the ASCE 7 seismic criteria for RISC-3 SSCs is recommended as an alternate approach with two modifications/improvements which provide the additional assurance appropriate for RISC-3 nuclear applications:

- Ensure the maximum considered earthquake (MCE) is taken as the nuclear plant site SSE (the MCE actually used in ASCE 7 is based on recent USGS hazard mapping of the entire United States but may or may not conform to the plant design basis SSE).
- Specific functional assessment for relays and contactors [(EPRI, 1990), (Hardy, 1990), and (EPRI, 1991)] contain recommended approaches for evaluating relay seismic capacities.

Implementation of this second criteria results in our RISC-3 criteria addressing both the issue of functionality during and after the earthquake. SSRAP concluded that relay anomalies could be precluded by performing a seismic adequacy review of relays (defined to include conventional relays along with switches and breakers). They also concluded that once the relay seismic adequacy had been addressed, that the earthquake experience data verified that the twenty classes of equipment exhibited seismic adequacy *during and following* the seismic event for

all other failure modes. In addition, the NRC statement in NUREG-1211 (NUREG, 1987) also confirms the demonstration of functionality for equipment pending confirmation of relay performance: "On the basis of the seismic experience data gathered to date, the only concern that remain on equipment functional capability is chatter of electrical relays." Since this seismic adequacy was established for RISC-1 components within the A46 program it is certainly also established for the lower safety significant RISC-3 components.

5.3.1 Use of Plant SSE Seismic Ground Motion in ASCE 7

ASCE 7 stipulates the use of a Maximum Considered Earthquake (MCE), which is based on a current USGS seismic hazard mapping. The MCE, corresponding to the specific site location, is selected from hazard maps and modified for site soil type (the hazard maps are normalized for a rock site condition). The plant SSE should be used for the MCE earthquake level (defined for application within the ASCE 7 methodology) to ensure that any RISC-3 design is conducted in accordance with the plant seismic design basis. The proposed amendment to 10 CFR 50 maintains the requirement that RISC-3 SSCs perform their safety related functions under design basis conditions (including seismic conditions) with "reasonable confidence." Thus, to ensure conformance to the plants licensing requirements, it is recommended that the ASCE 7 MCE level is set at the plant SSE level. Also, this would ensure that any site soil effects are correctly incorporated into the MCE, since the SSE ground motion was developed considering site specific conditions.

Appendix A provides a development of a generic demand level based on ASCE 7 methodology for building mounted component response, which would screen equipment for the SQUG Reference Spectrum at all building elevations. Thus, in a generic sense, the functionality of equipment is established with reasonable confidence, conditional on demonstration of anchorage adequacy and compliance with certain restrictions on equipment configuration. As discussed in the above section on the Seismic Experience-Based Approach, this part of the ASCE 7 methodology was adopted for that approach in order to verify functional performance on a generic basis for most plants.

For anchorage, ASCE 7 requires the use of ACI 318-02, which has a different approach for determination of anchorage capacity than the traditional factor-of-safety method (average pull-out test capacity/factor of safety) used by most utilities. However, as shown in Appendix A, both approaches yield the same approximate anchor design capacity. The major difference between a rigorous application of the ASCE 7 methodology and the Seismic Experience-Based Approach described previously is that the generic demand level would also be used for anchorage demand. Any plant specific commitments, such as II/I evaluations, would also need to be addressed.

5.3.2 Graded Performance of SSCs in DOE Nuclear Facilities

It is insightful to note that the DOE has established seismic criteria (ANS, 2003) that closely parallel the ASCE 7-02 approach being proposed for RISC-3 SSCs. For several years, the DOE has utilized a graded safety categorization for natural phenomena hazards (e.g., seismic) design of nuclear facilities. SSCs are placed in one of four performance categories according to their safety significance as determined by a rigorous safety analysis. Those SSCs determined to be significant contributors to facility safety are designated as "safety-class" and assigned a performance category (PC) of PC-3 or PC-4. Both of these performance categories are designed

to use nuclear power plant criteria including special treatment requirements, however, they are each associated with a different seismic demand level. In general, the categories PC-4 and PC-3 are equivalent to the risk-informed category RISC-1 (safety-significant, safety-related SSC). Non-safety-related SSCs are assigned a performance category of PC-1 and designed for the basic (non-essential facility) demand and acceptance criteria of the 2000 International Building Code[3], SSCs that are determined to not be significant contributors to facility safety but which are considered to contribute to defense-in-depth, are designed as "safety significant" and assigned a performance category of PC-2. In general, the category PC-2 is equivalent to the risk-informed category RISC-3. PC-2 SSCs are designed for the IBC requirements for essential facilities, which are intended to remain functional. The seismic demand, which is based on the recent USGS hazard mapping of the United States, and certain restrictions are imposed on SSCs (i.e., special treatment) to provide increased assurance of function. Thus, DOE has already established seismic design criteria for these PC-2 facility SSCs which provide the necessary confidence level for SSCs that contribute only to the defense-in-depth concept.

The IBC criteria endorsed by DOE for PC-2 SSCs is basically identical to the ASCE 7 approach being recommended in this guideline for RISC-3 components with the exception of the two upgrades (use of the SSE for demand and the specific assessment of relays and contactors) included within this recommended criteria to ensure conformance to the plant design basis and to ensure "function during" the seismic event.

5.4 Current Criteria Seismic Qualification Approaches

The seismic design basis for safety related equipment has been defined within plant documentation such as the FSAR and any plant specific regulatory commitments. In addition, many plants have modified their licensing bases to incorporate recent seismic qualification approaches such as the SQUG Generic Implementation Procedure (GIP) and the criteria for New and Replacement Equipment (NARE). These approaches are typically used to provide seismic qualification for RISC-1 components. While the criteria for RISC-3 components specifically allows for a reduced level of assurance from these RISC-1 methods, utilities can obviously use these same RISC-1 methods for the RISC-3 SSCs when it is determined to be more efficient or cost effective. Some of the reasons for utilizing the existing seismic design basis methods at a particular plant and/or for particular RISC-3 SSC's might include:

- Consistency of seismic qualification approaches within the plant
- Engineers require no additional training for an alternate approach
- Some SSCs may be sufficiently complicated that the more detailed design basis approach may be required
- Some RISC-1 methods are already very cost effective and no real benefit would be realized by using alternate methods (e.g., STERI for many subcomponents)
- Similar items may have already been qualified as RISC-1 and are readily available from a vendor

[3] The IBC 2000 has subsequently been updated with an IBC 2003 Code which defers to the ASCE 7-02 Code for seismic assessment of mechanical and electrical equipment.

These RISC-1 approaches are typically well understood by utility engineers and well documented by plant procedures. Thus, no further description/explanation will be presented within this report.

5.5 Part Design Change Approaches

In many cases, a modification to a given item of safety class equipment consists of the addition of a subcomponent. This is, in most cases, considered to be a design change for which the seismic adequacy of the entire host equipment item must then be re-evaluated. Usually the part being added is a small addition that does not affect the overall function of the equipment, but the effect on seismic performance requires evaluation. An example would be the addition of a terminal block to an electrical enclosure. If the terminal blocks had been replacement parts, the G-STERI methodology could be used for a RISC-1 enclosure to justify that the qualification status of the host equipment was not changed. However, the addition of components would require requalification of the host RISC-1 equipment. For a RISC-3 application, the addition of small seismically insensitive components would not, with reasonable confidence, degrade the host equipment as long as the weight of the additional components was limited to 10% of the total host equipment weight. Therefore, small modifications to RISC-3 equipment may be treated in the same manner as a replacement part using the procedures outlined in Chapter 6. In Figure 4-1, this RISC-3 process is indicated by a dashed line linkage to the replacement equipment/part method. In Figure 5-1, while the application of either STERI or NARE criteria is indicated, the important step of following plant engineering design change procedures is also indicated.
In the case of small modifications to RISC-3 items, the changes must be tracked to insure that subsequent design changes do not result in a cumulative weight change that exceeds 10% of the total host weight.

6
SEISMIC RISC-3 FOR REPLACEMENT EQUIPMENT AND PARTS

6.1 Overview of Component Replacement

The procurement process requires the review and identification of important design, material and performance characteristics for the replacement items. When items are not like for like replacements, alternate items must be evaluated. The function of the seismic technical evaluation for RISC-3 items is to determine requirements that provide reasonable confidence that replacement items will maintain their required seismic adequacy for their given application. For safety related RISC-1 components, several industry research projects have defined criteria for seismic technical evaluations in the STERI and G-STERI programs [(EPRI, 1993), (EPRI, 1997a)]. The results of these industry efforts combined with the damage/anomaly/failure results from the large database existing for earthquake and test experience has resulted in the identification of certain limitations to be considered by the procurement engineer as a part of the seismic technical evaluations for some of the more common replacement components.

EPRI developed a guideline for the seismic technical evaluation of replacement items (STERI) (EPRI, 1993). The STERI guideline is a seismic extension of the guidelines for the technical evaluation of replacement items (TERI) (EPRI, 1989), which deal with the overall procurement process of replacement parts for safety related equipment. The purpose of the seismic evaluation guideline is to simplify the procurement process for those spare part and replacement items which have seismic performance requirements necessary to maintain a plant's seismic design basis. The intent of the STERI guideline is to provide reasonable assurance that the original seismic qualification of both the replaced item and the host equipment is *maintained* when an equivalent replacement item (not a design change) is used. The STERI guideline does not provide methods for seismic qualification of new (i.e., additional) equipment or parts or any modifications of seismically qualified equipment items. The focus of the evaluation procedure is for maintaining the seismic adequacy of an equipment item which has an existing seismic qualification that meets the plant's seismic design basis. The STERI guideline considers three classes of screening evaluation:

- Seismic Insensitive Determination – No seismic failure mechanism is present which can affect the seismic adequacy of the item or host. The replaced item may be procured and installed without engineering technical evaluation.
- Seismic Ruggedness Determination – Identification of seismic bounding conditions related to seismic demand and specific restrictions regarding design details. An engineering technical evaluation is required before procurement and before installation.
- Other Evaluation – An item-specific equivalency technical evaluation must be conducted to assure that seismic qualification of the item and host is maintained.

EPRI has utilized the STERI guideline to develop generic seismic technical evaluation of replacement items (G-STERI) [(EPRI 1997a), (EPRI 1997b)]. The G-STERI evaluations have focused on the development of item-specific evaluations of seismically insensitive and seismically rugged items that are commonly procured as replacement items for plant equipment. Each plant may develop its own technical evaluations that augment the published G-STERI evaluations in order to procure common replacement items that are specific to the plant.

Equipment or component parts are changed out on an as-needed basis because of wear, defects, or preventative maintenance program considerations. This will be the most common application of the RISC-3 techniques being discussed within this report. The establishment of a group of SSCs designated as RISC-3 causes no sudden change to the plant or to plant procedures. Only when RISC-3 component parts are replaced does the possibility of alternate approaches arise. Figures 6-1 and 6-2 show the alternate paths of the RISC-3 replacement process.

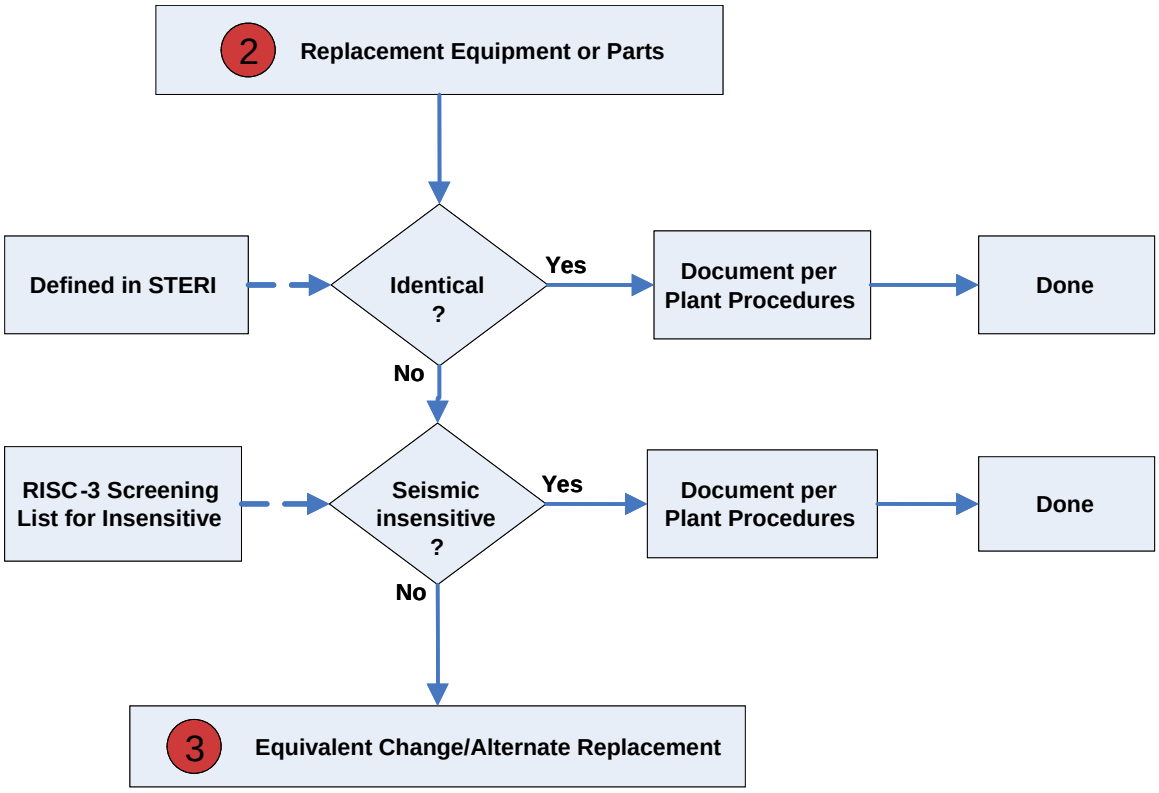

Figure 6-1
RISC-3 Replacement Equipment or Parts Process

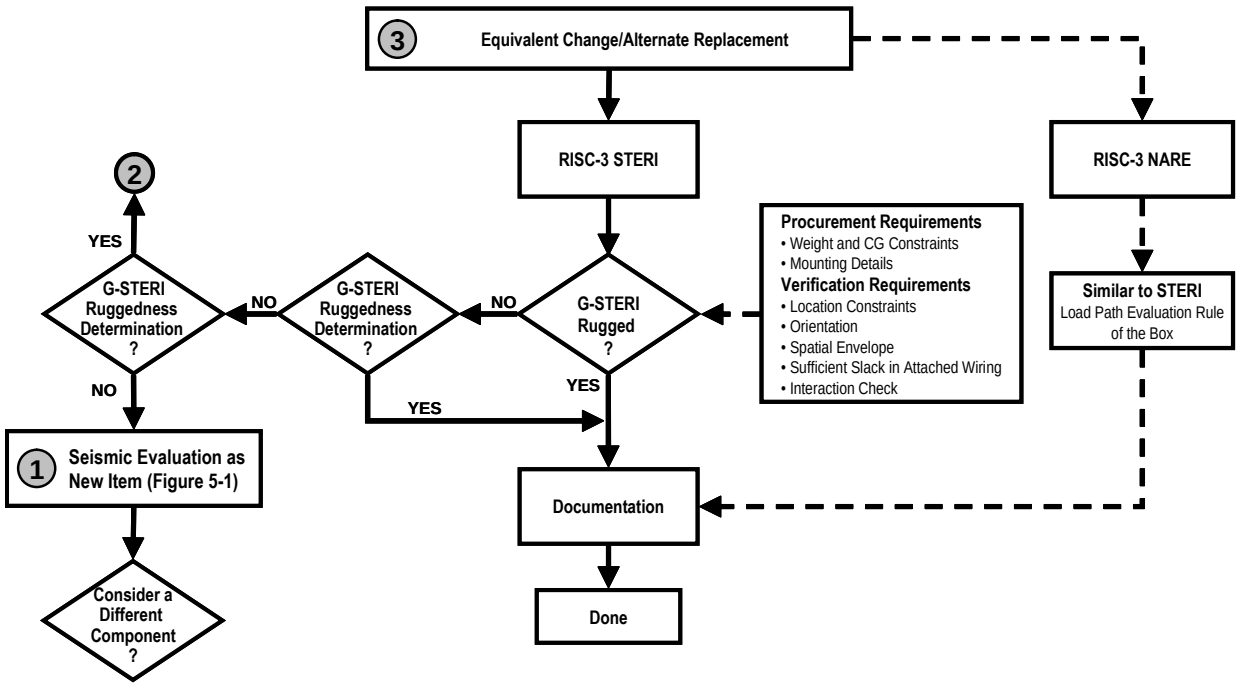

Figure 6-2
RISC-3 Equivalent Change/Alternate Replacement Process

Identical part replacement or replacement with a seismic insensitive item requires little procurement or engineering effort. An equivalent change or alternate replacement, however, invokes additional procurement considerations and engineering verification of installed adequacy.

If adopted as part of the plant procurement process, the NARE procedures may also be used as an alternate method. In general, the NARE procedures incorporate the STERI procedures plus additional verification procedures for item or component part replacement within the subset of equipment whose seismic adequacy was verified using SQUG GIP procedures.

6.2 Categories of Equipment or Component Part Replacement

It must be noted that the fundamental goal of the STERI process is to show that the existing qualification of the host equipment is maintained by the component part replacement. As discussed in Section 5, the addition of new components to a host, while actually a modification, can be evaluated similar to a replacement part as long as the change of the host configuration is small and the process is tracked according to the plant engineering change order procedures. The NARE process is similar to the STERI process but different terminology is used.

The RISC-3 component parts can be screened in four ways:

- Like-for-Like (Identical) Replacement Items – no evaluation required.
- Seismic Insensitive Replacement Items – no evaluation required.
- Seismically Rugged Items – additional procurement requirements and installation verification requirements must be verified.

- Potentially Seismic Sensitive - if an alternative component cannot be found, then the procedures for new items, items requiring modification requiring design change, or current criteria must be considered.

6.2.1 Like for Like or Identical Replacement Items

According to EPRI 1993 and EPRI 1989, an identical item is defined as "the same part, make and model number, which exhibits the same technical and physical characteristics." In this case, there is no change to the host and no technical evaluation is necessary. Such items may be directly procured and installed without affecting the existing seismic qualification basis.

6.2.2 Seismic Insensitive Item

According to EPRI 1993, a seismic insensitive item is defined as "an item whose performance is not affected by earthquake loads. Seismic insensitive replacement items have no specific attributes." A total of 13 G-STERI seismically insensitive items, as shown in Table 6-1, have been identified (EPRI, 1997b). These items may also be directly procured and installed without affecting the existing seismic qualification basis.

Table 6-1
G-STERI Seismic Insensitive Evaluations

Index	G-STERI Technical Evaluation	EVAL NO	Rev
1	Fuse	C-94001	Rev 3
2	Mechanical O-Ring	C-94002	Rev 1
3	Motor/Engine Oils	C-94003	Rev 1
4	Terminal Blocks – 600V	E-94001	Rev 1
5	PC Board Items	E-95002	Rev 1
6	Fuse Blocks	E-95005	Rev 0
7	Thermal Overload Bimetallic Heater	E-95007	Rev 0
8	Solenoid Coil	E-95019	Rev 0
9	Indicating Lamp	E-95023	Rev 0
10	Indicating Light Assembly	E-95030	Rev 0
11	Mechanical Seals	M-95009	Rev 0
12	Filter	M-95010	Rev 0
13	Diaphragm	M-95011	Rev 0

6.2.3 Seismically Rugged Items

A total of 59 G-STERI seismically rugged items have been identified and evaluated (EPRI, 1997b). Each evaluation contains a set of applicable bounding conditions (limitations related to seismic demand), operability limits, and specific conditions (limitations related to the item design and installation features). A review of the entire group of G-STERI seismically rugged items indicates that a sub-set of 23 of the G-STERI seismically rugged items may be identified that have either bounding or limiting conditions (i.e., applicable demand or operability limits) that are required to be verified in order to maintain the seismic adequacy of the replaced item or host. These items, as shown in Table 6-2, can be divided into four basic groups:

1. Items for which the seismic evaluation has indicated that functionality cannot be demonstrated as adequate during a seismic event but remain functional after the event,

2. Items which are only functional after a seismic event but whose calibration may also be affected by the shaking,

3. Items which are functional both during and after a seismic event but whose calibration may also be affected by the shaking, and

4. Items for which functionally both during and after a seismic event can only be demonstrated up to a given demand limit. This group of items must be individually considered for each replacement application.

Table 6-2
G-STERI Components with Bounding or Limiting Conditions

Index	GSTRI Technical Evaluation	EVAL NO	Rev	Seismic Capacity Basis	Function During & After?	Calibration Assured
1	Volt/Amp/Frequency Meter	E-95009	Rev 0	se	After	Yes
2	Electric Analog Indicating Meter	E-95010	Rev 0	se	After	Yes
3	Rotometer	E-95018	Rev 0	se	After	Yes
4	Thermostat	E-95032	Rev 0	dl	After	Yes
5	Level Switch	I-95004	Rev 0	dl	After	Yes
6	I&C Temperature Switch	I-95009	Rev 0	dl	After	Yes
7	Strip Chart Recorder	I-95012	Rev 0	se	After	Yes
8	Potentiometer	E-95017	Rev 0	se	After	No
9	Pressure/Differential Pressure Switch	I-95003	Rev 0	dl	After	No
10	Electro-Pneumatic Transducer	I-95005	Rev 1	se	After	No

Table 6–2
G-STERI Components with Bounding or Limiting Conditions (Continued)

Index	GSTRI Technical Evaluation	EVAL NO	Rev	Seismic Capacity Basis	Function During & After?	Calibration Assured
11	Pnuematic Controller	I-95014	Rev 0	dl	After	No
12	Temperature Indicating Controller	I-95015	Rev 0	dl	After	No
13	Converter (I/V)	E-95033	Rev 0	se	Yes	No
14	Servoamplifier: Strip Chart Recorder	I-94001	Rev 1	se	Yes	No
15	Transmitter (Pressure, Flow)	I-95002	Rev 0	dl	Yes	No
16	Differential Pressure Indicator	I-95013	Rev 0	dr/se	Yes	Yes
17	Circuit Breaker, Molded Case	E-95004	Rev 1	dl	Yes	Yes
18	Rotary Switches	E-95006	Rev 1	dl	Yes	Yes
19	Battery Cell	E-95013	Rev 0	dl	Yes	Yes
20	Position Switches	E-95016	Rev 0	dl	Yes	Yes
21	Solenoid Operated Valve	M-94003	Rev 1	dl	Yes	Yes
22	Woodward Governors	M-95006	Rev 0	dl	Yes	Yes
23	Air Piston Actuator	M-95008	Rev 0	dl	Yes	Yes

dl = demand limit
se = seismic experience (both testing and earthquake experience)
dr = design review

The remaining sub-set of 36 G-STERI items, as shown in Table 6-3, require *no bounding or limiting conditions* to be verified in order to maintain the seismic adequacy of the replaced item or host. The 9 items identified as complex are active electrical devices judged to not be suitable for a RISC-3 modification of the STERI process.

Table 6-3
G-STERI Seismic Rugged Evaluations Without Bounding or Limiting Conditions

Index	G-STERI Technical Evaluation	EVAL NO	Rev	Complex
1	Power Supplies AC/DC	E-95001	Rev 0	Yes
2	Printed Circuit Board Assembly	E-95003	Rev 1	Yes
3	Thermal Overload Bimetallic Relay	E-95008	Rev 1	Yes
4	Current Transformer	E-95011	Rev 0	
5	Control Transformer	E-95012	Rev 0	
6	AC/DC Motor	E-95014	Rev 0	
7	Solid State Protective Relay	E-95015	Rev 0	Yes
8	Heater Element	E-95020	Rev 0	
9	Disconnect Switch	E-95021	Rev 0	
10	Rectifier	E-95024	Rev 0	Yes
11	Timer	E-95025	Rev 0	Yes
12	Annunciator	E-95026	Rev 0	Yes
13	Voltage Regulator	E-95027	Rev 0	
14	Voltage Suppressor	E-95028	Rev 0	
15	Electrical Connector	E-95029	Rev 0	
16	Power Conditioner	E-95031	Rev 0	Yes
17	Capacitors on Printed Circuit Boards	E-97001	Rev 0	Yes
18	Pressure Regulator	I-95001	Rev 0	
19	Pressure Gauge	I-95006	Rev 0	
20	Instrument Valve	I-95007	Rev 0	
21	Thermocouple	I-95010	Rev 1	
22	RTD	I-95011	Rev 1	
23	LVDT (Non-Spring-Loaded)	I-95016	Rev 0	
24	Pump Impellers	M-94001	Rev 1	
25	Hoses Single Line	M-94002	Rev 1	
26	Gate and Globe Valve	M-95001	Rev 0	
27	Check Valve	M-95002	Rev 0	
28	Horizontal Pump	M-95003	Rev 0	
29	Vertical Pump	M-95004	Rev 0	
30	Fan	M-95005	Rev 0	
31	Pressure Relief Valve (1” and below)	M-95007	Rev 0	
32	Coupling Flexible	M-95012	Rev 0	
33	Roller Bearing	M-95013	Rev 0	
34	Steam Trap	M-95014	Rev 0	
35	Damper	M-95015	Rev 0	
36	Compressor	M-95016	Rev 0	

6.3 Modified STERI, G-STERI, and NARE Approaches for RISC-3

The remaining 27 G-STERI items, not identified as complex in Table 6-3, are candidates for being considered in a RISC-3 modification of G-STERI. These selected items all remain functional during and after a seismic event and do not have any bounding conditions that limit seismic demand. In addition, the specific conditions for this group of items are simple statements of attribute requirements. They may be procured and installed in a host by verifying the G-STERI specific conditions. The specific conditions for these items can be separated into 1) procurement requirements and 2) verification requirements.

This sub-set of 27 items is designated as ***RISC-3 seismically adequate***. Appendix C provides the modified procurement and verification requirements for each item. Procurement requirements are simple statements of replacement item form, fit, and function as well as any material limitations (e.g., no cast iron). Verification requirements are caveats, which may be verified after item installation. They are similar to SQUG GIP walkdown caveats (such as identification of any seismic interactions) and can easily be put into a walkdown check sheet form. The RISC-3 seismically adequate procedure essentially is similar to a SQUG evaluation where the replacement item is considered to be part of an existing equipment item. The item is procured and installed with reasonable confidence that it will be successfully verified as adequate. If issues are identified during the walkdown evaluation of the installed replacement item, then it would be treated similar to a SQUG outlier and the outlier condition evaluated.

7
RISC-3 PIPING SEISMIC EVALUATION

7.1 Background

Piping systems and attached components may also be designated as RISC-3. Given that a piping system and its component supports have been fully qualified and certified according to the ASME B&PV Code, the active support elements (e.g., snubbers) must be continually inspected and subjected to in-service testing to ensure proper function. The primary purpose of this testing is to assure function under normal operation and other possible thermal transient events, with only a secondary concern on possible function during a seismic event. While such support components have been positioned to keep the piping stresses and deformation within code limits during a seismic event, the consequences of a device not allowing thermal expansion during a thermal transient event is very severe and can greatly reduce piping fatigue life. Thus, if a qualified piping system is designated as RISC-3, it can be reconsidered under ASME Class 2 or 3 rules since only reasonable confidence of adequate seismic performance is required. If snubbers can be removed and the piping system re-evaluated as seismically adequate under ASME Class 2 or 3 rules, then both the thermal reliability is increased and a cost savings incurred due to reduced in-service testing. It should be noted that several utilities have already conducted snubber reduction programs using more realistic damping and seismic demand using ASME Class 1 rules.

7.2 Piping Systems

A piping system consists of a pressure retaining boundary (pipe) which is routed along a path which requires component supports placed at intervals to maintain both the position of the pipe and to control the stresses in the piping component under internal pressure, temperature and imposed external loads. Pressure and temperature are specified design conditions. The primary external loads are those due to deadweight and both (1) inertial loading caused by the seismic response of the piping system due to structure acceleration support motions and (2) the imposed loading due to differential seismic displacements of the support locations within the structure. The design of piping systems within nuclear plants has been one of the major design efforts during plant construction. Piping design has also been subject to changing design criteria during the past 30 years. As a result, each plant has a somewhat unique set of plant specific piping design criteria which is documented in the FSAR or other specified criteria documents for each plant. Often these documents are subject to considerable negotiations during plant licensing efforts. References TVADNE 2001a and TVADNE 2001b are examples of plant specific design criteria developed to demonstrate that non-Category I piping systems that have proximity to Category I systems will have position and pressure retention (no spray) under normal plus SSE conditions. The pressure retaining components are subject to the requirements of the ASME B&PV Code which is updated every three years. Many plants are licensed to older ASME B&PV

Code versions which have criteria that differ from the current Code (2003). It should be noted that the ASME B&PV Code is specified by 10 CFR 50 as the governing requirement to be met for pressure boundary components. The ASME B&PV Code mandates stress limits as acceptance criteria that must be met for imposed operating conditions and external loads. However, the Code is not prescriptive on the analysis methods used to obtain the stress state of the pressure boundary. Each plant has documented analysis procedures and assumptions that are made (usually with differing levels of conservatism) in order to conduct the analyses. In order to simplify the analyses, the components supports were often designed with constraints on the support stiffness and allowed support displacements under the imposed loads. This approach results in a very stiff piping system for which snubbers must be utilized to accommodate thermal growth yet act as supports during a dynamic event. This is in contrast to piping systems used in industrial processes which are designed without such constraints, resulting in very flexible piping systems. Such flexible piping systems have had satisfactory performance (both position and pressure retention) in actual earthquakes. Thus for RISC-3 piping, it would appear that design modification efforts should focus on the component support configuration. As long as the revised support configuration will satisfy current ASME Code stress requirements for the pressure components under normal plus SSE conditions, then the component supports may be evaluated for revised criteria that focuses upon assuring position retention. Only the SSE event is considered; a separate evaluation for OBE conditions is not necessary for RISC-3 piping systems. If such RISC-3 systems have reasonable confidence of adequate performance for SSE conditions, then lesser conditions may be considered to be also satisfied. It is judged that a redesignated RISC-3 system may be evaluated for alternate support conditions by considering the following evaluation criteria. For RISC-3 piping supports, an evaluation shall be documented as a calculation demonstrating compliance with the criteria contained herein.

7.3 Screening Evaluation

Piping systems may be requalified by screening. EPRI NP-6041 (EPRI, 1991b) provides general screening criteria. The EPRI Piping Seismic Verification Guidelines (EPRI, 2003) provide more detailed criteria.

Piping systems may be requalified by following the EPRI Piping Seismic Verification Guidelines. These guidelines require:

- A walkdown (and/or drawing review) to identify seismic vulnerabilities
- Limited analytical review of piping system supports
- Detailed analysis for resolution of outliers

First, the piping and support are reviewed for inclusion rules (see Section 3.2 of the EPRI guidelines) on specific hardware or plant features to show that the piping system is represented within the earthquake experience data. The in-plant review also addresses prohibited features that may result in damage, as evidenced by the earthquake experience data.

Second, a sample of pipe supports is selected for the analytical review. The EPRI guidelines direct the sample selection to include bounding supports. The sample selection should include supports that encompass the diversity of the reviewed systems. The analytical reviews show the supports have adequate seismic margin. The analytical review criteria are presented in Section 4 of the EPRI guidelines.

7.4 Pressure Component Evaluation

The pressure integrity of piping systems shall be demonstrated by dynamic analysis. The current plant design seismic response for the SSE shall be used as input. A damping value of 5% shall be used rather than the values used in the design basis documents or alternatively CC N-411 damping may be used. The general criterion for pressure component acceptance is:

DL + Po + SSE' < ASME Level D, where,

DL = Dead Load, including permanently installed equipment

Po = Operating pressure

SSE' = Inertial loads due to the SSE

and where ASME refers to the appropriate section of the current edition (2003) of the ASME B&PV Code. The above load combination is only for seismic evaluation. The piping system shall be separately shown to satisfy any plant specific operating or accident conditions which are independent of seismic loads.

Seismic piping stresses are evaluated against Level D service limits as per the current edition of ASME III NC-3650. For Level D, the primary stress is determined by means of the following equation:

$$S = B_1 \frac{P_{\max} D}{2t} + B_2 \left(\frac{M_A + M_B}{Z} \right) \leq 3S_h, 2S_y$$

S_h is the lesser of $S_y/1.6$ or $S_u/4$ at operating temperature. Material properties are as specified in the code. M_A is the resultant seismic moment due to pressure and dead weight effects while M_B is the resultant seismic moment. Past versions of the ASME code have used stress criteria limits that have ranged from $2.4S_h$ to $2S_y$.

Alternatively, the following equation from ASME B31.1 may be used:

$$S = .75i \left(\frac{M_A + M_B}{Z} \right) \leq 3S_h, 2S_y$$

In calculating the resultant seismic moment, M_B, the dynamic effects of anchor displacement due to earthquake may be included to simplify the evaluation (this is a conservative approach). However, if they are not included, they must then be evaluated separately in accordance with the ASME Code criteria. If the resultant seismic moment due to anchor displacements is denoted by M_C, then:

$$S = B_2 \left(\frac{M_C}{Z} \right) \leq 4S_y$$

7.5 Component Support Evaluation

The criteria, for design of RISC-3 piping supports and associated supplemental steel, is summarized in Table 7-1, along with the accompanying notes. This RISC-3 pipe support design criteria address both potential falling hazard (position retention) and spray hazard (pressure boundary retention) concerns and is based on the criteria presented in TVADNE 2001b. Certain commonly encountered support issues require separate consideration.

7.5.1 Friction

RISC-3 pipe support designs which allow unrestrained uni-directional pipe expansion movement do not require an evaluation of the supports' ability to resist friction forces.

7.5.2 Stiffness/Deflection Requirements

Pipe support stiffness/deflection limitations are not required for seismic RISC-3 supports. The use of maximum displacement limits are often used for RISC-1 piping supports to insure rigid support conditions. Stiffness or deflections limitations for seismic RISC-3 pipe supports are not recommended based on actual earthquake performance of flexible piping systems in utility and industrial facilities.

7.5.3 Rod Hangers

On rod hangers for RISC-3 piping, vertical uplift loads due to seismic response may be neglected. Impact loads on RISC-3 rod hangers that experience uplift need not be explicitly addressed as this concern is covered by the factors of safety (see Table 7-1).

The effect of bending of RISC-3 rod hangers (with fixed-end connections) due to pipe movements shall be evaluated for fatigue effects, considering fatigue failure test data (SQUG, 1991) less two standard deviations.

7.5.4 Lug Design Requirements

Lugs in RISC-3 piping systems shall be evaluated using the load combinations for Level D conditions. The following general design requirements apply:

1. All lugs to be welded to pipe must be of a compatible material with the pipe. This material must meet the requirements of the applicable code and class for the process pipe to which it is attached.
2. Installation of lugs in an area which requires welding over an existing weld or on piping components, such as tees, elbows, and reducers, is not allowed.
3. All attachments should be made on straight runs of pipe with no lug weld edge any closer than the minimum distance of rmtn from any welds or other discontinuities where rm is the mean pipe radius and tn is the nominal pipe wall thickness.

4. For all new designs, a clearance of 2tn+2 inches or 6 inches, whichever is greater, (where tn is nominal pipe wall thickness) or 1/2-inch for other classes of pipe) is required to permit access for weld inspection and testing (NDE and ISI) of all welded attachments.
5. When lugs are added to piping as a part of a seismic dynamic restraint, shims may be added to achieve a specified clearance of 1/16 inch between lug face and the support.
6. In determining the number of shear lugs to be considered effective the following criteria shall be used: for piping 8” and larger in diameter a minimum of 4 lugs shall be used and half of the lugs shall be considered effective. If this results in excessive local stresses in the attachment, additional lugs may be considered effective if the gap (on the same side of the structure) between the lug and supporting structure is verified to be the same. When more than half of the lugs are considered effective the flexibility for each load path shall be evaluated and the load distributed to the lugs accordingly.
7. For piping sizes less than 8” in diameter a minimum of 2 lugs shall be provided and both considered effective. If more than two lugs exist then half of the lugs shall be considered effective. Additional lugs may be considered effective if the gap (on the same side of the structure) between the lug and supporting structure is verified to be the same. If more than two lugs exist and more than half are considered effective, the flexibility for each load path shall be evaluated and the load distributed to the lugs accordingly.

7.5.5 Riser Supports

1. Riser supports being used on vertical RISC-3 piping to support deadweight or hydrostatic test loads shall be designed to support the total support load on either arm. This does not apply to supports utilizing springs or snubbers.

2. When riser clamps are used to support vertical RISC-3 pipe, shear lugs shall be welded to the pipe to prevent slippage. Associated lugs shall be qualified with consideration of load distribution and the provisions indicated above.

7.5.6 Riser Clamps

Friction type riser clamps shall not be used on RISC-3 piping.

7.5.7 Terminating Anchor

Where portions of mechanical systems are Category I or RISC-3 and the remaining portions not seismically classified, the systems have been seismically qualified to a terminating anchor (or other appropriate analysis problem termination) beyond the defined boundary such as a valve. Pipe supports located on piping designated RISC-3 shall be designed to maintain integrity so as to prevent damage to nuclear safety related features located in the vicinity.

Table 7-1
Support Design Loads and Allowable Stresses for RISC-3 Pipe Supports
(Based on TVADNE 2001b)

Item Acceptance	Criteria for Normal + SSE
Flexural and Tensile Stresses	The lesser of 0.7 S_u and 1.2 S_y (check local buckling in non-compact sections if instability may result)
Shear Stresses	The lesser of 0.42 S_u and 0.72 S_y
Bolt Stresses	The lesser of 0.75 S_u and the minimum specified S_y
Compressive Loads	0.9 P_{cr}
Anchorage	Use ultimate capacities and criteria from SQUG 1991 along with a factor of safety of 3.0 (for expansion anchors) and a complete review or installation and design parameters as detailed in SQUG 1991.
Standard Component Supports and Hardware	See Notes 2 and 3

Abbreviations for Table 7-1:
S_u = Structural steel ultimate stress
S_y = Structural steel yield stress
P_{cr} = Compression capacity

Notes for Table 7-1

1. *Refer to Piping Design Criteria for calculation of loads and movements for RISC-3 pipe supports. Pipe supports with potential non-ductile failure modes must satisfy these normal plus seismic stress allowable values. Pipe supports with ductile failure modes do not require evaluation. If a thermal evaluation is also required, the piping analyst will supply the pipe support designer with these loads.*

2. *Acceptable loads shall be:*

   - *The manufacturer's recommended Level D load rating.*

   Or in cases where the test data is available:

   - *Mean ultimate capacity with a factor of safety of 2.0 with the additional requirement that all test data must be above the calculated capacity.*

3. *Saddles without center stiffeners (MSS-SP58 type 39A and 39B), heavy duty clamps for pipe sizes less than 4 inches, adjustable clevis (MSS-SP58 type 1), and beam attachments shall be qualified by detailed analysis using the capacities in the table above. The design of U-Bolt Clamps requires development of separate specifications. Where vendor allowables are used, capacities shall be adjusted such that factors of safety consistent with the criteria presented in Table 7-1 are applied.*

4. *Local effects check for pipe support connections to civil structural steel shall be performed in accordance with AISC Structural Steel Specifications (AISC, 1989). Increases above the basic AISC allowables are permitted as provided in Table 7-1.*

8
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A
RISC-3 COMPONENT SEISMIC ASSESSMENT USING ASCE 7-02

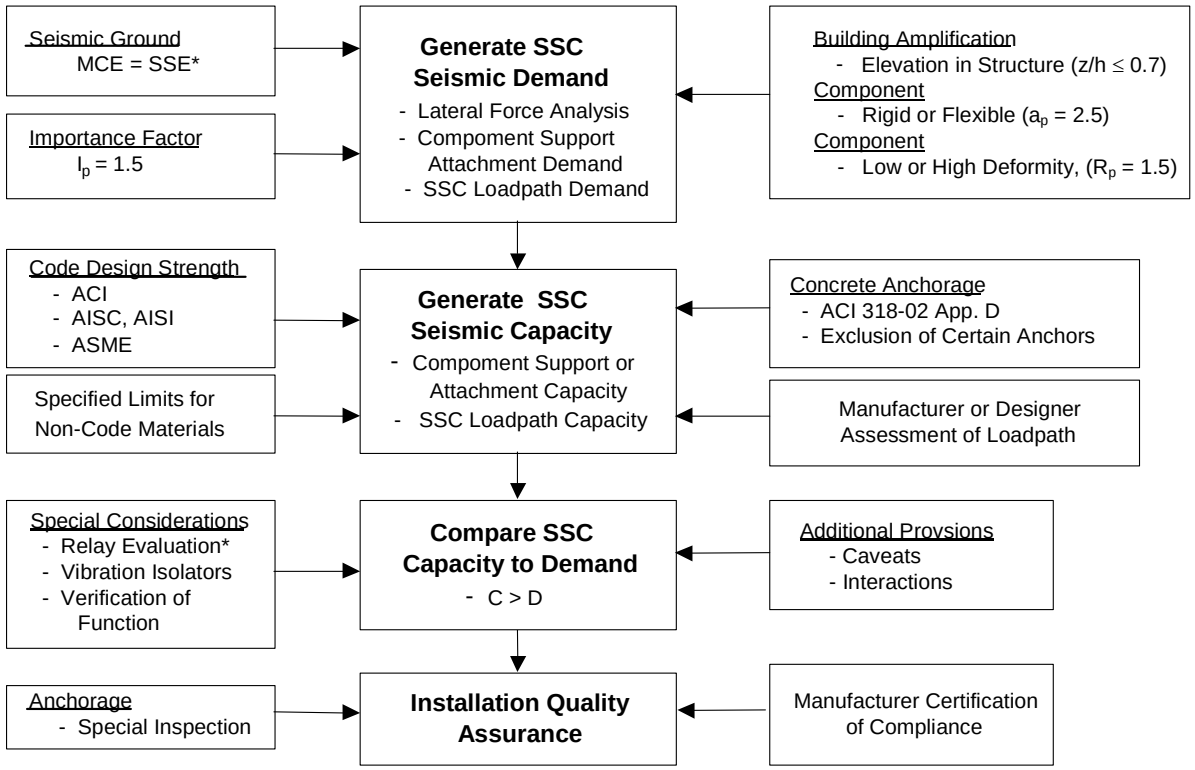
This Appendix provides an outline of the ASCE 7-02 (ASCE, 2002) seismic requirements for assessment of electrical and mechanical components (i.e., SSCs) needed for the continued operation of an essential facility as defined in ASCE 7-02. The 2002 revision of ASCE Standard 7, *Minimum Design Loads for Building and Other Structures*, is based on the 2000 edition of the National Earthquake Hazards Reduction Program *NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures* (FEMA 302 and 303). The seismic design requirements, for architectural, mechanical, and electrical components, contained in the 2003 edition of the *International Building Code* (IBC), explicitly incorporate the ASCE 7 requirements by direct reference. The ASCE 7 approach is judged to provide reasonable confidence with respect to the seismic adequacy of ground or building mounted components. Thus, the ASCE 7 seismic design criteria is recommended for RISC-3 SSCs as an alternative design approach.

A.1 Demand Criteria

The basic approach used in ASCE 7-02 is similar to any seismic design evaluation approach in that the seismic demand and the seismic capacity are generated using a prescribed set of steps and then the capacity is compared to the demand. The seismic evaluation approach taken within ASCE 7 is relatively simple and fairly easy to apply once the various analysis simplification factors are understood (engineers familiar with structural building code design from IBC, NEHRP or UBC will already be familiar with the terminology and the factors). Figure A-1 shows the basic steps for the evaluation.

A.1.1 Ground Motion Definition

The first step is to define the ground motion for the site. ASCE 7 stipulates the use of a Maximum Considered Earthquake (MCE), which is based on the current USGS seismic hazard mapping for the United States associated with an approximate 2500 year return period. The MCE, corresponding to the specific site location, is selected from hazard maps and modified for site soil type (the hazard maps are normalized for a rock site condition). The SSE for nuclear plant design is often associated with a 10,000 year return period. The proposed amendment to 10 CFR 50 maintains the requirement that RISC-3 SSCs perform their safety related functions under design basis conditions (including seismic conditions) with “reasonable confidence.” Thus, to ensure conformance to the design basis requirements of a given plant, it is recommended that the ASCE 7 MCE level is set at the SSE level (as defined in Appendix A to 10 CFR 100 or the plant license) to ensure that any RISC-3 design is conducted to at least the plant SSE level. Also, this would ensure that any site soil effects are correctly incorporated into the MCE, since the SSE ground motion was developed considering the site specific conditions.



**not considered in ASCE 7; enhancements added for RISC-3 design evaluations*

Figure A-1
ASCE 7 Basic Methodology

ASCE 7 requires that the determination of SSC seismic capacity is based on use of nationally recognized structural codes such as AISC, ACI, etc., using strength design methods (i.e., load factor and resistance factor design methods). The consensus judgment of the developers of the NEHRP Provisions (base document for ASCE 7) was that the use of current code values of component strength values provides a margin of at least 1.5 against unacceptable behavior. Thus, ASCE 7 considers design ground motion levels that are 1/1.5 or 2/3 of the level associated with the MCE. Since the USGS seismic hazard mapping is presented in terms of spectral acceleration (5% damping) associated with 5 Hz and 1 Hz, the plateau region of the free-field ground design spectrum is defined as $S_{DS} = 2/3\ S_{MS}$, where S_{MS} is the USGS mapped value of spectral acceleration at a frequency of 5 Hz which has been adjusted to reflect the effects of any site soil response. The ZPA of the ground design spectrum is taken as ZPA = 0.4 S_{DS} . The general shape of the ground design spectrum is prescribed in ASCE 7 based on the values of spectral acceleration at 1 Hz and 5 Hz given on the USGS hazard maps. An example ASCE 7 design spectrum derived using mapped hazard values of 0.375g for 5Hz and 0.140g for 1Hz is shown in Figure A-2.

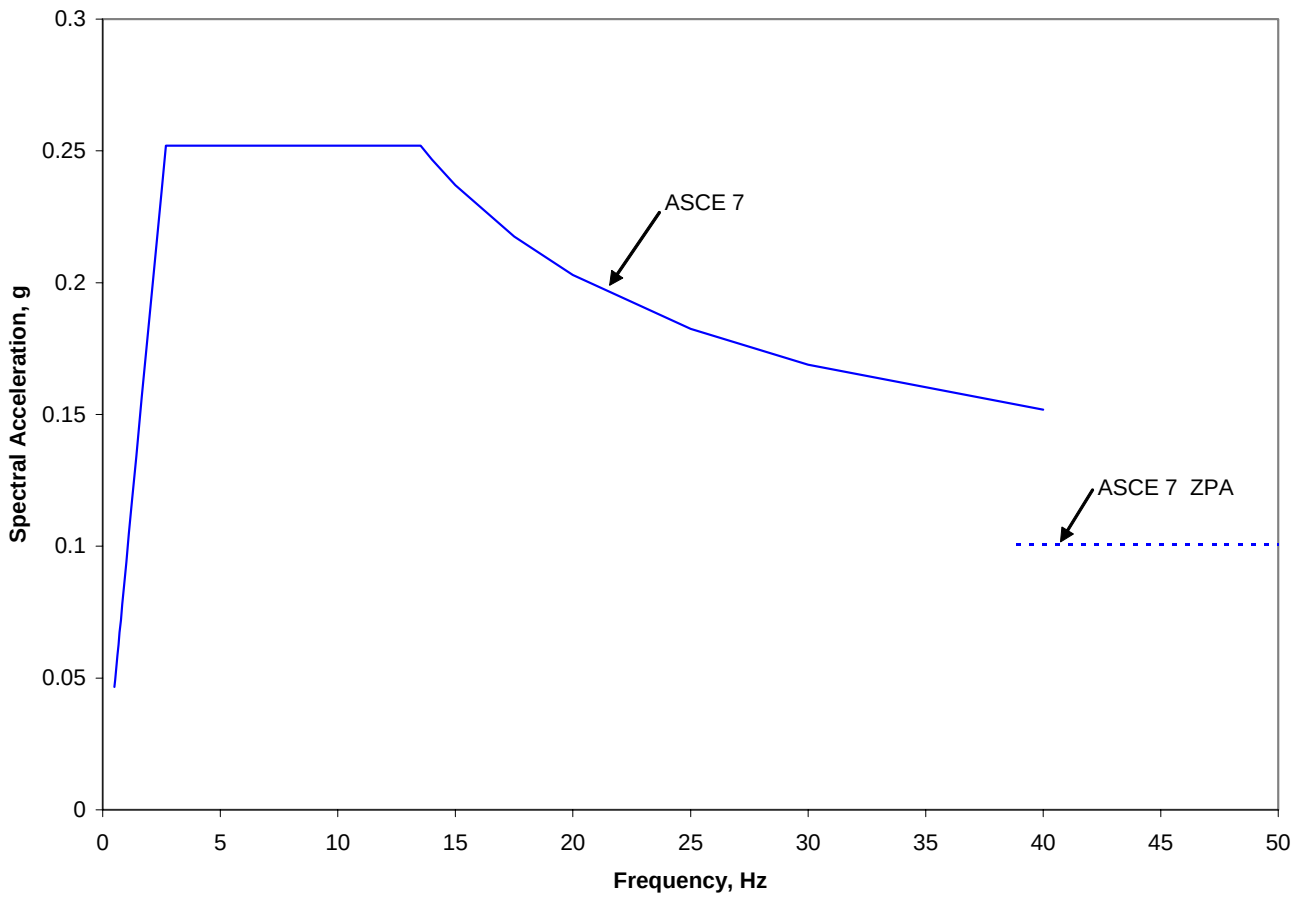


Figure A-2
Example Plant ASCE 7 Design Spectrum

A.1.2 In-Structure Demand Determination

The next step is to compute the seismic demand for a component mounted within a building. ASCE 7 does not develop floor spectra to establish component demand. Instead, ASCE 7 uses the concept of equivalent lateral force to evaluate/assess the seismic response of structure mounted mechanical/electrical components. The seismic design force, F_p, to be applied at the component's center-of-gravity and distributed according to the component's mass distribution is taken as:

$$Fp = 0.4\ ap\ SDS\ [1/(Rp/Ip)\ (1 + 2\ z/h)\ Wp$$ **Equation A-1**

where F_p has the following bounds:

$$0.3\ \underline{S}_{DS}\ I_p\ W_p \leq F_p \leq 1.6\ \underline{S}_{DS}\ I_p\ W_p$$ **Equation A-2**

In the above equations, I_p is the component importance factor, a_p is a component amplification factor, R_p is a component response modification factor, W_p is the component weight, and $\underline{S}_{DS}$ is the design spectral response acceleration, normalized by g. The in-structure amplification is taken as a linear function of the elevation of the component location within the structure with respect to the structure base. This structural amplification stems from the (1 + 2 z/h) term in Equation A-1 and varies from a value of 1.0 to a value of 3.0. In Equation A-1, z is the in-structure height of the component attachment point, where z ranges from 0 to h, with h being the building roof height with respect to the free-field ground or grade level of the site. The ASCE 7 factor definitions and recommended RISC-3 default values are summarized in Table A-1. Further discussion of the factors appears in the following:

Table A-1
ASCE 7 Component Demand Factors

ASCE 7 Nomenclature	Factor Definition	Factor Value	Recommended Value for RISC-3	Comment
MCE	Maximum Considered Earthquake	USGS mean hazard map value (for 2500 yr return period)	SSE as defined in plant design basis (generally associated with 10,000 yr return period)	SSE is more conservative motion level than USGS hazard level
S_{MS}	Maximum spectral acceleration of MCE	Spectral acceleration (5% damping) of MCE at 5 Hz	Maximum spectral acceleration (5% damping) of SSE at 5 Hz	SSE Response Spectra is associated with 84% non-exceedance level while MCE is a mean level (additional conservatism)
S_{DS}	Design spectrum	= 2/3 x S_{MS}	= 2/3 x SSE	Design margin of 1.5
F_p	Component force	Equation A-1	Equation A-1	Applied at component C.G.
W_p	Component weight	Component mass x g	Component mass x g	F_p/W_p is acceleration at component C. G.
I_p	Importance factor	= 1.5	= 1.5	Essential Facility
R_p	Response modification factor	= 1.5	= 1.5	I_p/R_p = 1 is default value
a_p	Component amplification factor	= 1.0 (rigid) = 2.5 (flexible)	= 2.5	Flexible component assumed as default value

The component importance factor, I_p, is the key factor used in ASCE 7 to identify components that require additional assurance of continued function. The component importance designation of, I_p = 1.5, triggers the consideration of additional design provisions that must be considered as well as additional quality assurance requirements. It should be noted that ASCE 7 contains some

conditions that exempt components from code design requirements based on the seismic design category (SDC) of the facility (designated by a letter A-F) and the seismic use group (SUG) assigned to the facility. The SDC, which is actually a category bin based on seismic input level, is determined by tables provided in ASCE 7 which assign the SDC based on the SUG assigned to the facility and the mapped values of Maximum Considered Earthquake ground motion in terms of spectral acceleration values. For the purposes of application of ASCE 7 to RISC-3 design, a nuclear power plant is assumed to be a SUG III facility (i.e., a facility designated as essential). Thus, for application of ASCE 7 provisions to design of nuclear plant RISC-3 SSCs, the component importance factor should be taken as $I_p = 1.5$ and any defined exemptions in ASCE 7 based on SDC are to be ignored.

The component response modification factor R_p can effectively be considered to be a ductility factor. In ASCE 7, R_p varies from 1.5 to 5.0 depending upon the material characterization of the component being graded between brittle (low ductility) and high ductility. In Equation A-1, the term, $[1/(R_p/I_p]$, is purposely written as a reciprocal ratio to illustrate that the purpose of the importance factor is to reduce the response modification factor, allowing a more elastic design basis (load path stresses less than yield level). For complete elastic design, $R_p/I_p = 1.0$, which is consistent with an $I_p = 1.5$ coupled with a minimum value of $R_p = 1.5$ which is assigned to components with brittle material in the component support load path. For application of ASCE 7 provisions to design of nuclear plant RISC-3 SSCs, it is recommended that the various values of component R_p tabulated in ASCE 7 be ignored, and the ratio, $R_p/I_p = 1.0$, is to be used in Equation A-1. In this manner, SSCs are designed assuming the highest level of seismic response with stresses less than yield levels.

The component amplification factor, a_p, varies from 1.0 to 2.5, depending upon the identification of the component as either rigid or flexible. In ASCE 7 vernacular, a rigid component is defined as having a fundamental frequency equal to or greater than 16.7 Hz and a flexible component is defined as having a fundamental frequency less than 16.7 Hz. In order to determine which value of a_p should be used, ASCE 7 requires that the natural frequency of the equipment component, including the effect of component supports and the attachment to the structure, be estimated. Since most mechanical and electrical equipment, as mounted within a building, will have frequencies less than 16.7 Hz, a default value of, $a_p = 2.5$, will typically be used to generate the seismic design force. In this default case, the requirement for frequency estimation is unnecessary. Only the case of a known rigid component, such as a pump, would a value, $a_p = 1.0$, be used. The example R_p values tabulated in ASCE 7 and paired with a_p coefficients for each class of component should be ignored for the design of RISC-3 SSCs since ductility based reduction is not be used to obtain the design loads.

Given that $R_p/I_p = 1$, the ratio, F_p/W_p, can be interpreted as the maximum value of the acceleration response of a single-degree-of-freedom oscillator attached to the building at elevation z. Assuming 5% damping, this value is, by definition, the spectral acceleration value associated with building elevation z. Thus, for a component mounted on a floor midway between the free-field or site grade level and the roof of a building, the maximum value of the effective “floor spectrum” would be a factor of 2 greater than the respective maximum value of the free-field ground spectrum.

ASCE 7 does not specifically address the determination of the seismic demand on rigid sub-components mounted within equipment at locations other than the center-of-gravity. The maximum mounting point demand may be estimated by considering simple idealizations of equipment response. For example, many types of equipment enclosures can be idealized as a uniform shear beam which has an acceleration response at the top of the equipment which is approximately 1.3 times the peak value of a floor response spectrum. The bounding case would be a effective uniform rigid body rocking on a base compliance (effective rotational spring) which yields an acceleration response at the top of the equipment which is approximately 1.5 times the peak value of a floor response spectrum.

A.1.3 Development of Generic Demand Screening Level

Now, given default values of $a_p = 2.5$, $R_p/I_p = 1.0$, and $I_p = 1.5$ along with $\underline{S}_{DS} = 2/3$ SSE, where SSE is the maximum value of the site design response spectrum (5% damping, normalized by g) defined in the plant design basis or FSAR, Equations A-1 and A-2 may be simplified as

$$F_p / W_p = 2/3 \text{ SSE } (1 + 2\, z/h) \leq 1.6 \text{ SSE} \qquad \textbf{Equation A-3}$$

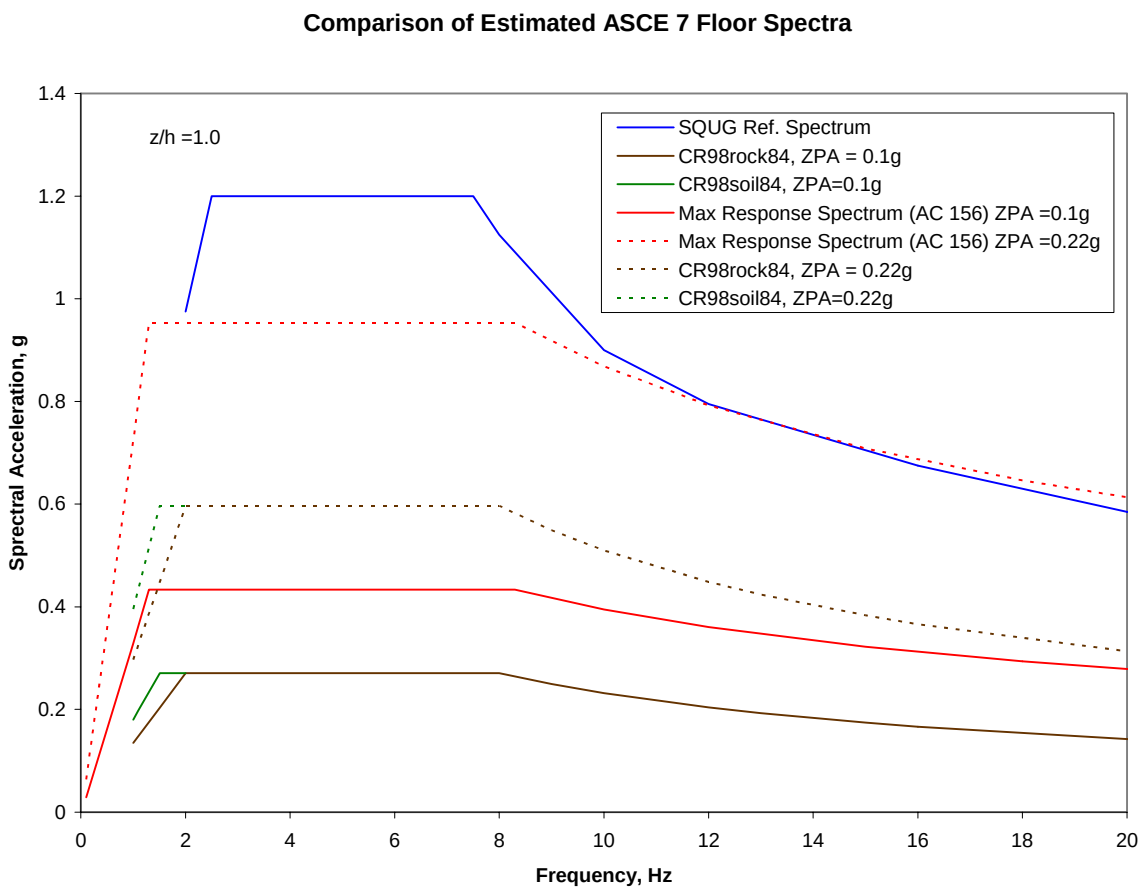


Figure A-3
Example ASCE 7 Floor Spectra

From Equation A-3, it may be noted that the limiting value of F_p/ W_p = 1.6 SSE is obtained at z/h = 0.7 and F_p/ W_p is less than the SSE for z/h ≤ 0.25. As noted above, ASCE 7 provides the maximum spectral value for a floor response spectrum but does not address the shape of the resulting floor spectrum. Reference 15 (ICC AC 156), however, does provide the guidance for construction of a floor spectrum using the ASCE 7 base design spectrum. Figure A-3 has been prepared using the guidance of Reference 15, with F_p/ W_p = 1.6 SSE chosen as maximum value for the plateau region of the floor spectrum.

For the CEUS, all but two nuclear plant sites will have a ZPA ≤ 0.22g. Assuming an 84% non-exceedance NUREG/CR-0098 (Reference 25) spectrum shape characterized by the ratio SSE/ZPA = 2.71, this will yield a value of maximum value of spectral acceleration (5% damping) given by SSE ≤ 2.71 (0.22) = 0.596g and a corresponding F_p/ W_p ≤ 0.95g. This is the upper bound floor spectrum shown in Figure A-3. The second floor spectrum is associated with a ZPA = 0.10g which is the minimum ZPA design level for a SSE. The SSE (ground) levels associated which each floor spectrum are also shown in Figure A-3.

As can be noted in Figure A-3, the GIP Reference Spectrum (1.20g) effectively bounds the floor spectrum associated with a ZPA = 0.22g. For 97% of the CEUS sites, the floor spectrum associated with a ZPA = 0.22g may be considered as a generic upper bound demand screening level. Using the ASCE 7 approach, all CEUS sites can utilize the GIP Reference Spectrum to provide an assurance of functional performance.

It must be noted that the ASCE 7 component design force level, F_p, is a *factored load* to be directly used to determine the *required strength* of the component attachments and equipment supports. Also, there are specific criteria for special design considerations such as seismic interaction, vibration isolators and for recommended anchorage installation (undersized washers, weld quality, friction clips, etc.).

An additional recommendation to be added to the ASCE 7 design requirements is that relays receive an additional review to verify their operability during the earthquake since the ASCE 7 code does not address that specific situation. The methodology described in the Generic Implementation Procedure (GIP) or within the plant specific seismic design procedures would be acceptable approaches for relay review.

The ASCE 7 design approach outlined above provides the necessary assurance that the critical SSCs will remain functional for the continued operation of essential facilities (e.g., hospital equipment, fire equipment, fire stations, power generating stations) in a seismic event. ASCE 7 is a consensus national standard which has been developed by a broad group of experts in the fields of seismology, seismic design, dynamic response, and the documented effects of actual earthquake on building structures and their associated components and equipment systems. The recommendation within this guideline relative to RISC-3 components is to meet the ASCE 7 requirements for essential components using the more conservative demand levels associated with the site SSE and default values for the ASCE 7 design factors that yield upper bound design force levels. This recommended criteria is actually beyond that required in the most recent national and international building codes and standards for essential facilities. Conservatism is introduced by the use of the plant SSE (usually associated with a 10,000 year return period) instead of the 2500 year return period earthquake level given in the USGS national earthquake

hazard mapping. Additional conservatism is also introduced since the SSE is selected at the 84% non-exceedance level while the USGS mapped values of spectral acceleration are mean values. It has been judged by the utility task force to represent a reasonable confidence level of performance in accordance with the 10 CFR 50.69 requirements.

A.2 Anchorage Criteria

For RISC-3 SSCs evaluated to the ASCE 7-02 requirements, the design of anchorage and quality control of anchor installation is one of the most important design and construction tasks undertaken to assure the required seismic capacity. Concrete anchors can either be directly cast-in-place concrete (embedments) or post-installed (expansion and undercut anchors) concrete anchors. In the U.S., the code design requirements (e.g., ACI-318) for anchoring to concrete have been recently revised. This section reflects these revisions for anchorage of RISC-3 SSCs within a nuclear plant. It is anticipated that most RISC-3 components will use post-installed anchors rather than cast-in-place concrete embedments.

RISC-3 components are required to be anchored with the anchorage proportioned to provide the required strength to resist the ASCE 7 design force, F_p, applied to the anchored component using the demand level referenced to the plant SSE. The force in the component attachment to the structure is to be determined by the independent application of a horizontal design force, applied independently in each orthogonal direction (longitudinal and lateral), which are then each combined with the component attachment force due to a vertical seismic input force of * 0.2 (SSSE/1.5) D, where D is the fraction of the dead weight of the component applied to the connected part. For shallow anchors (embedment-length to diameter ratio less than 8), ASCE 7 requires that the component response modification factor used to determine the design force, F_p, be assigned a reduced value of $R_p = 1.5$. The intent of the ASCE 7 provisions is to then provide an anchorage design where required strength of the anchorage is determined according to the ACI-318 code. During the past few years, a new design procedure (Concrete Capacity Design, CCD) for fastening equipment to concrete has been developed based on test research both in the U.S. and Europe. There has been considerable recent code development work on this subject. ASCE 7 references the 2002 ACI-318 document directly as the necessary design requirements for strength design of attachments to concrete. The new ACI 318 provisions have “borrowed” the ACI 349 concept of requiring ductile behavior of embedment steel. It should be noted that the determination of required strength based on new cyclic test requirements for post-installed anchors represent a significant departure from the past practice of obtaining allowable design capacity values by using average static test pullout and shear test capacity data divided by a factor of safety ranging from 3 to 5.

Since only a few expansion anchor manufacturers have marketed anchors which meet the new cyclic testing requirements for seismic induced loads, it is reasonable to outline a set of criteria for interim use that will allow the use of currently available published static test data to meet the intent of the new ACI provisions. The basic design requirements of the new provisions for post-installed anchors are based on extensive testing by the manufacturer to provide reference data, reliability data, and service-condition data which then is used to establish the required design strength of an anchor for comparison to the factored design load. Reference tests of post-installed anchors, both static and dynamic, are used to establish failure modes in both uncracked and cracked concrete. Reliability tests are concerned with the sensitivity of the anchor to installation

issues such as drill hole tolerance in both cracked and uncracked concrete. Service-condition tests involve determination of the effects of edge distance and spacing of anchors as well as cyclic loading that qualifies the anchor for seismic conditions. In the following, it will be assumed that the manufacturer of a given post-installed anchor type has complied with the static test requirements of ACI-318-02 using uncracked concrete.

The design strength values are based on the 5% fractile (90 % confidence that 95% of test strengths in uncracked concrete exceed the nominal strength) with modifications for edge proximity, anchor spacing, and depth of concrete member if such data is available. The use of the 5% fractile test strength is the most radical departure from the current practice of the average test strength. Given a set of "n" anchor test values, the 5% fractile strength is determined using one-sided tolerance limits for a normal distribution as

$$P_{5\%} = P_{ave}\ (1\text{-}K\ COV)$$

where P_{ave} is the average on the n test values, COV is the coefficient of variation of the n test values, and where K is the tolerance factor given by the following table:

n, Sample Size	K, Tolerance Factor
3	5.31
4	3.96
5	3.40
6	3.09
7	2.89
8	2.76
10	2.57
15	2.33
20	2.21
30	2.08
50	1.97

The coefficient of variation is given by the ratio, s/P_{ave}, where s is the standard deviation of the n test values. In general, the minimum test sample size used by the manufacturer should follow the recommendations of ASTM E488:

COV	Minimum Sample Size
<12%	5
12-15%	10
>15%	30

Now, given a set of n anchor test values (usually published by the anchor manufacturer for each anchor size for static tests in uncracked concrete), the 5% fractile strength may be determined using the applicable COV value. For determination of anchor strength for use in RISC-3 design, an anchor will be considered acceptable only if all n static test values are the result of concrete breakout or steel failure without excessive slip. If any of the test samples fail by pullout or pull-through of the anchor alone, that anchor type shall not be acceptable for RISC-3 use.

Since the nominal strength value under the ACI-318 provisions are based on the strength in cracked concrete, the nominal strength should be taken as:

$$N'_n \text{ or } V'_n = P_{5\%} / 1.4$$

as an estimate of the cracked strength only if test data in uncracked concrete is available. For RISC-3 design, anchors shall be located such that the distance to any edge or adjacent anchor is greater than 1.5 h_{eff}, where h_{eff} is the effective embedment depth measured from the point of bearing contact to the concrete surface, unless manufacturer test data is available for proximity or free edge effects. If the building analysis indicates that an anchor is located within a region of the structure for which cracking is not expected (i.e., for which the concrete tensile stress is less than the concrete modulus of rupture), then the nominal strength in uncracked concrete may be used.

The design requirements for a post-installed anchor in tension or shear used for seismic loading are then given by

$$0.75\ \phi_n\ N'_n \geq N_u$$

$$0.75\ \phi_v\ V'_n \geq V_u$$

where ϕ_k is the strength reduction factor as specified in ACI 318 ($\phi_n = 0.75$ and $\phi_v = 0.75$ may be used as default values), 0.75 is an additional reduction imposed by ASCE 7 on SDC = C, D, E, or F facilities, N'_n and V'_n are the nominal strength in tension and shear, respectively, and N_u and V_u are the factored anchor loads in tension and shear, respectively.

Combined tension and shear on anchors should be evaluated using the interaction relation

$$N_u/(0.75\ \phi_n\ N'_n) + V_u/(0.75\ \phi_v\ V'_n) \leq 1.2$$

if $N_u > 0.2\ (0.75\ \phi_n\ N'_n)$ and $V_u > 0.2\ (0.75\ \phi_v\ V'_n)$, otherwise full strength is used in tension or shear.

As an example, consider the existing static tension test data for an anchor with 10 test failures that resulted in concrete breakout. The COV of the test sample is 0.15 and the test average failure load is P_{ave}. The design strength for seismic loading is then

$$0.75\ \phi_n\ N'_n = 0.75\ (0.75)\ \{1-(2.57)(0.15)\}/1.4\ P_{ave} = 0.247\ P_{ave} = P_{ave}\ /4.05$$

The design procedure outlined above allows existing static test data to be used to establish anchor seismic capacity. This will allow the RISC-3 design to proceed in the absence of published cyclic test data. It should be noted that while the new ACI-318 procedure used to establish the design strength used for anchor design is different from past procedures using a factor of safety applied to average pullout test values, the final results are similar (a safety factor of 4 is common in commercial anchor design practice). It should also be noted that the current ICC Acceptance Criteria for post-installed anchor Evaluation Reports require cyclic testing in order for the anchors to be have a seismic rating. To date, only a few anchor types have been fully tested with evaluation reports issued to manufacturers. The cyclic testing requirement is to insure that anchors will not slip under reverse cycle loading and pullout of the hole.

The reliability of the anchor is controlled by requiring that the installation of all anchors is accomplished with continuous special inspection to insure full compliance with the manufacturers installation instructions (correct drill bits, hole cleaning, torque requirements, etc.). Although not required by the ASCE 7, it should be noted that California school and hospital construction quality assurance procedures require approximately 10% of all anchors installed to be proof loaded to a serviceability force level of $(0.75\ \phi_n\ N'_n)/1.4$ without appreciable slip.

A Quality Assurance Plan (QAP) will be required to be issued by the anchorage designer which fully documents the installation procedures as required by the manufacturer. The installer should have a QCP which documents installation procedures and specifies drill bits, hole cleaning procedures, anchor setting, torque requirements, etc. If random proof testing is used as a QC method, the procedure and acceptance criteria should be fully detailed in the QAP. Such requirements for QAPs are standard nuclear plant practice.

B
SEISMIC EXPERIENCE-BASED CAVEATS FOR RISC-3 ITEMS

Section 5.2 describes the recommended approach for the evaluation of new equipment and modifications using an experience-based approach. The recommended methodology consists of the basic 4 screens associated with experience-based methods:

1. Anchorage – no changes recommended from RISC 1 Approach
2. Interaction – no changes recommended from RISC 1 Approach
3. Capacity to Demand – propose to address generically using the ASCE 7 approach outlined in Appendix A which will eliminate the need for site specific and component specific evaluations for functionality review
4. Caveats – reduced set of caveats required based on actual failures and damage in earthquakes and tests.

This Appendix documents the critical caveats which are recommended to be utilized for the RISC-3 program.

Section 3 of this report discusses the concept of "reasonable confidence" with respect to seismic RISC-3 criteria. Several RISC-1 approaches have been developed in the past which are also based on the use of earthquake and test experience (e.g., the SQUG Generic Implementation Procedure and the SQUG New and Replacement Equipment procedure). The intent of this RISC-3 criteria is to include the critical elements (caveats) of these earlier RISC-1 experience-based procedures which were based on ***actual damage and failures***, and to streamline the seismic assessment process in terms of requirements that originated based on other considerations. Thus, the basic elements of requiring anchorage reviews, interaction reviews, capacity to demand demonstration and specific caveats associated with failures and damage in earthquakes and tests will be maintained in the recommended procedure for RISC-3.

Table B-1 contains all of the caveats for the 20 classes of equipment defined within the Generic Implementation Procedure (GIP) developed by SQUG. Each of the caveats required for a RISC 1 evaluation are listed within this table. The caveats in standard print are recommended to be maintained within this RISC-3 program because they were judged to directly affect the seismic capacity of the component relative to the response levels generated for an SSE. Those caveats that are printed in italics text are recommended to be removed for this RISC-3 methodology, since we are judging that reasonable assurance can be demonstrated without them. For these caveats in italics, Table B-1 also lists the basis for the recommendation to remove them for RISC-3 applications.

Table B-1
Seismic RISC-3 Criteria for Replacement and New Equipment

*(*Caveats in italics are proposed to be removed for Seismic RISC-3 evaluation purposes)*

1) Horizontal Pumps	Caveat*	Criteria for Eliminating for RISC-3
	Equipment is included in earthquake experience equipment class	
	Driver and pump connected by rigid base or skid	
	No indication that shaft does not have thrust restraint in both axial directions	
	No risk of excessive nozzle loads such as gross pipe motion or differential displacement	
	Base vibration isolators adequate for seismic loads	
	Attached lines (cooling, air, electrical) have adequate flexibility	Horizontal Pumps are typically compact and have high frequencies due to their design for high RPM operation loads. Thus their displacements are relatively small. There have been no known instances of horizontal pump damage due to attached line displacements.
	Relays mounted on equipment evaluated	
2) Vertical Pumps	**Caveat**	**Criteria for Eliminating for RISC-3**
	Equipment is included in earthquake experience equipment class	
	Casing and impeller shaft not cantilevered more than 20 feet, with radial bearing at bottom to support shaft	
	No risk of excessive nozzle loads such as gross pipe motion or differential displacement	
	Attached lines (cooling, air, electrical) have adequate flexibility	
	Relays mounted on equipment evaluated	

Table B-1
Seismic RISC-3 Criteria for Replacement and New Equipment (Continued)

3) Fluid-Operated Valves	Caveats*	Criteria for Eliminating for RISC-3
	Equipment is included in earthquake experience equipment class	
	No cast iron body	
	No cast iron yoke (for spring-operated pressure relief or piston-operated valves)	
	Mounted on 1 inch diameter pipe or larger	This caveat originated based on the SSRAP concern that large valves might be placed into small diameter piping systems and have negative results in an earthquake. From all the hundreds of facilities that have been reviewed following major earthquakes with the thousands of valves included, there has not been a single reported valve anomaly resulting from this concern relative to valves mounted on piping less than 1 inch. Thus, we have reasonable confidence in the ruggedness of valves typically designed for 1 inch piping systems.
	Centerline of pipe to top of operator within restrictions of Figure B.7-1 of Appendix B, or yoke can take static 3g load (for air-operated diaphragm, lightweight piston-operated, and spring-operated pressure relief valves)	This caveat originated based on the predominant number of valves within the database falling under this curve. The earthquake experience data base has some limited number of valves that exceed the boundaries in B.7-1 and none of these cases has resulted in damage following a major seismic event. The size of the valve relative to the diameter of the piping is not a critical characteristic relative to seismic capacity. We judge that reasonable confidence exists after removing this caveat.

Table B-1
Seismic RISC-3 Criteria for Replacement and New Equipment (Continued)

3) Fluid-Operated Valves	Caveats*	Criteria for Eliminating for RISC-3
	Centerline of pipe to top of operator within restrictions of Figure B.7-2 of Appendix B, or yoke can take static 3g load (for piston-operated valve of substantial weight)	This caveat originated based on the predominant number of valves within the database falling under this curve. The earthquake experience data base has some limited number of valves that exceed the boundaries in B.7-2 and none of these cases has resulted in damage following a major seismic event. The size of the valve relative to the diameter of the piping is not a critical characteristic relative to seismic capacity. We judge that reasonable confidence exists after removing this caveat.
	Actuator and yoke not braced independently from pipe	
	Attached lines (air, electrical) have adequate flexibility	
4a) Motor-Operated Valves	**Caveat***	**Criteria for Eliminating for RISC-3**
	Equipment is included in earthquake experience equipment class	
	No cast iron body	
	No cast iron Yoke	
	Mounted on 1 inch diameter pipe or larger	This caveat originated based on the SSRAP concern that large valves might be placed into small diameter piping systems and have negative results in an earthquake. From all the hundreds of facilities that have been reviewed following major earthquakes with the thousands of valves included, there has not been a single reported valve anomaly resulting from this concern relative to valves mounted on piping less than 1 inch. Thus, we have reasonable confidence in the ruggedness of valves typically designed for 1 inch piping systems.

Table B-1
Seismic RISC-3 Criteria for Replacement and New Equipment (Continued)

4a) Motor-Operated Valves	Caveat*	Criteria for Eliminating for RISC-3
	Centerline of pipe to operator within restrictions of Figure B.8A-1 of Appendix B, or yoke can take static 3g load	This caveat originated based on the predominant number of valves within the database falling under this curve. The earthquake experience data base has some limited number of valves that exceed the boundaries in B.8A-1 and none of these cases has resulted in damage following a major seismic event. The size of the valve relative to the diameter of the piping is not a critical characteristic relative to seismic capacity. We judge that reasonable confidence exists after removing this caveat.
	Actuator and yoke not braced independently from pipe	
	Attached lines (electrical) have adequate flexibility	
4b) Solenoid-Operated Valves	**Caveat***	**Criteria for Eliminating for RISC-3**
	Equipment is included in earthquake experience equipment class	
	No cast iron yoke	
	No cast iron body	
	Centerline of pipe to operator within restrictions of Figure B.8B-1 of Appendix B, or yoke can take static 3g load	This caveat originated based on the predominant number of valves within the database falling under this curve. The earthquake experience data base has some limited number of valves that exceed the boundaries in B.8B-2 and none of these cases has resulted in damage following a major seismic event. The size of the valve relative to the diameter of the piping is not a critical characteristic relative to seismic capacity. We judge that reasonable confidence exists after removing this caveat.
	Actuator and yoke not braced independently from pipe	
	Attached lines (electrical) have adequate flexibility	

Table B-1
Seismic RISC-3 Criteria for Replacement and New Equipment (Continued)

5) Medium Voltage Switchgear	Caveat*	Criteria for Eliminating for RISC-3
	Equipment is included in earthquake experience equipment class	
	2.4 KV to 4.16 KV rating	Switchgear beyond the 4.16 KV rating exist in the earthquake experience database. These larger switchgear have performed very well during earthquakes and have not exhibited failure modes beyond those captured by the remaining caveats for transformers.
	Internally mounted potential and/or control power transformers are restrained to prevent damage to or disconnection of contacts	
	Attached weight (excluding conduit) less than about 100 lbs per cabinet bay	This caveat is not necessary. The cabinet anchorage and load path are already evaluated as part of the RISC-3 seismic Criteria.
	Adjacent cabinets which are close enough to impact, or sections of multi-bay cabinets, are bolted together if they contain essential relays	
	Externally attached items rigidly anchored	
	General configuration similar to ANSI C37.20 Standards	This caveat is not necessary. The load path and anchorage caveats address the principal concern that exists for panels. Earthquake experience for international facilities that have equipment not necessarily conforming to ANSI standards have not resulted in identifying this design type to be a critical characteristic to seismic capacity.

Table B-1
Seismic RISC-3 Criteria for Replacement and New Equipment (Continued)

5) Medium Voltage Switchgear	Caveat*	Criteria for Eliminating for RISC-3
	Cutouts in lower half of cabinet sheathing less than 30% of width of side panel wide and less than 60% of width of side panel high excluding bus transfer compartment	This caveat is not necessary. The cabinet anchorage and load path are already evaluated as part of the RISC-3 seismic Criteria.
	All doors secured by latch or fastener	
	Relays mounted on equipment evaluated	
6) Transformers	**Caveat***	**Criteria for Eliminating for RISC-3**
	Equipment is included in earthquake experience equipment class	
	4.16 KV rating or less	Transformers beyond the 4.16 KV rating exist in the earthquake experience database. These larger transformers have performed very well during earthquakes and have not exhibited failure modes beyond those captured by the remaining caveats for transformers.
	For floor-mounted dry- and oil-type unit, transformer coils are positively restrained within cabinet	
	For 750 kVA or larger units, coils are top braced or adequacy shown by evaluation	
	For 750 kVA or larger units, 2-inch clearance is provided between energized component and cabinet	
	For 750 kVA or larger units, the slack in the connection between the high-voltage leads and the first anchor accommodates 3-inch relative displacement	
	For wall-mounted units, transformer coils anchored to enclosure near enclosure support surface	This caveat not necessary, the load path and the anchorage are already evaluated as part of the RISC-3 seismic review.

Table B-1
Seismic RISC-3 Criteria for Replacement and New Equipment (Continued)

6) Transformers	Caveat*	Criteria for Eliminating for RISC-3
	For floor-mounted units, anchorage does not rely on weak-way bending of cabinet structures under lateral forces	This caveat originated from an analytical concern by SSRAP that postulated that analyses could potentially show this to be a weak area. All the earthquake experience and even a fragility test at CPSES with this weak-way bending design have shown this design not to be a concern. Based on the test and earthquake experience data, we have reasonable confidence that this weak way structural steel support design has adequate seismic capacity and that this caveat can be removed.
	Adjacent cabinets which are close enough to impact are bolted together if they contain essential relays	
	All doors secured by latch or fastener	
	Relays mounted on equipment evaluated	
7) Fans	**Caveat***	**Criteria for Eliminating for RISC-3**
	Equipment is included in earthquake experience equipment class	
	Drive motor and fan mounted on common base	
	For axial fan with long shaft between fan and motor, shaft supported at fan as well as motor	This failure mode has not been observed on any fan in either the earthquake experience database or in shake table testing of air handlers. This failure mode involving shaft support induced failures can thus, (with reasonable confidence) be removed from the caveat list for seismic RISC-3 purposes.
	No possibility of excessive duct distortion causing binding or misalignment of fan	
	Base vibration isolators adequate for seismic loads	
	Attached lines (electrical) have adequate flexibility	

Table B-1
Seismic RISC-3 Criteria for Replacement and New Equipment (Continued)

8) Air Handlers	Caveat*	Criteria for Eliminating for RISC-3
	Equipment is included in earthquake experience equipment class	
	Anchorage of heavy internal components is adequate; internal vibration isolators have seismic stops to limit uplift and lateral movement	
	All doors secured by latch or fastener	
	No possibility of excessive duct distortion causing binding or misalignment of any internal fan	
	Base vibration isolators adequate for seismic loads	
	Attached lines (water, air, electrical) have adequate flexibility	
	Relays mounted on equipment evaluated	
9) Chillers	**Caveat***	**Criteria for Eliminating for RISC-3**
	Equipment is included in earthquake experience equipment class	
	Evaporator and condenser tanks reasonably braced between themselves for lateral forces without relying on weak-way bending of steel plates or structural steel shapes	This caveat originated from an analytical concern by SSRAP that postulated that analyses could potentially show this to be a weak area. All the earthquake experience and even a fragility test at CPSES with this weak-way bending design have shown this design not to be a concern. Based on the test and earthquake experience data, we have reasonable confidence that this weak way structural steel support design has adequate seismic capacity and that this caveat can be removed.
	Base and/or compressor/motor vibration isolators adequate for seismic loads	
	Relays mounted on equipment evaluated	

Table B-1
Seismic RISC-3 Criteria for Replacement and New Equipment (Continued)

10) Air Compressors	Caveat*	Criteria for Eliminating for RISC-3
	Equipment is included in earthquake experience equipment class	
	Base vibration isolators adequate for seismic loads	
	Attached lines have adequate flexibility	
	Relays mounted on equipment evaluated	
11) Motor-Generators	**Caveat***	**Criteria for Eliminating for RISC-3**
	Equipment is included in earthquake experience equipment class	
	Main driver and driven equipment connected by a rigid support or skid	
	Base vibration isolators adequate for seismic loads	
	Attached lines have adequate flexibility	
	Relays mounted on equipment evaluated	
12) Distribution Panels	**Caveat***	**Criteria for Eliminating for RISC-3**
	Equipment is included in earthquake experience equipment class	
	Contains only circuit breakers and switches	
	All latches and fasteners in door secured	
	Adjacent cabinets which are close enough to impact, or sections of multi-bay cabinets, are bolted together if they contain essential relays	

Table B-1
Seismic RISC-3 Criteria for Replacement and New Equipment (Continued)

12) Distribution Panels	Caveat*	Criteria for Eliminating for RISC-3
	Wall- or floor-mounted NEMA-type enclosure	This caveat is not necessary. The load path and anchorage caveats address the principal concern that exists for panels. Earthquake experience for international facilities that have equipment not necessarily conforming to NEMA type enclosures have not resulted in identifying this design type to be a critical characteristic to seismic capacity.
	Relays mounted on equipment evaluated	
13) Batteries on Racks	**Caveat***	**Criteria for Eliminating for RISC-3**
	Equipment is included in earthquake experience equipment class	
	Plates of the cells are of lead-calcium flat-plate, Plante or of Manchex design	
	Each individual battery weighs less than 450 lbs	This caveat originated based on the predominant number of batteries within the earthquake experience database falling below this 450 lb value. The failure modes for batteries are based on material, aging and other support considerations. No seismic failures can be attributed to the size/weight of the batteries based on testing and earthquake results. Thus we have reasonable confidence in demonstrating the seismic capacity of batteries while removing this caveat.
	Close-fitting, crush resistant spacers fill two-thirds of vertical space between cells	
	Cells restrained by end and side rails	
	Racks have longitudinal cross bracing	

Table B-1
Seismic RISC-3 Criteria for Replacement and New Equipment (Continued)

13) Batteries on Racks	Caveat*	Criteria for Eliminating for RISC-3
	Wood racks evaluated to industry accepted standards	
	Batteries greater than 10 years old specifically evaluated for aging effects	
14) Battery Chargers & Inverters	**Caveat***	**Criteria for Eliminating for RISC-3**
	Equipment is included in earthquake experience equipment class	
	Solid state type	
	For floor-mounted, transformer positively anchored and mounted near base, or load path is evaluated	
	Base assembly of floor-mounted unit properly braced or stiffened for lateral forces	This caveat is not necessary. The cabinet anchorage and load path are already evaluated as part of the RISC-3 seismic criteria.
	For wall-mounted units, transformer supports and bracing provide adequate load path to the rear cabinet wall	This caveat is not necessary. The cabinet anchorage and load path are already evaluated as part of the RISC-3 seismic criteria.
	All latches and fasteners in doors secured	
	Relays mounted on equipment evaluated	
15) Engine-Generators	**Caveat***	**Criteria for Eliminating for RISC-3**
	Equipment is included in earthquake experience equipment class	
	Driver and driven equipment connected by a rigid support or common skid	
	Base vibration isolators adequate for seismic loads	
	Attached lines (cooling, air, electrical) have adequate flexibility	
	Relays mounted on equipment evaluated	

Table B-1
Seismic RISC-3 Criteria for Replacement and New Equipment (Continued)

16) Instruments on Racks	Caveat*	Criteria for Eliminating for RISC-3
	Equipment is included in earthquake experience equipment class	
	No computers or programmable controllers	
	Steel frame and sheet metal structurally adequate	
	Adjacent racks which are close enough to impact or sections of multi-bay racks are bolted together if they contain essential relays	
	Natural frequency relative to 8 Hz limit considered	This caveat originated with respect to use of Method A. We are not using Method A for RISC-3 Applications and no failures have occurred in earthquake or testing experience attributed to a natural frequency below 8 Hz issue.
	Attached lines have adequate flexibility	
	Relays mounted on equipment evaluated	
17) Temperature Sensors	**Caveat***	**Criteria for Eliminating for RISC-3**
	Equipment is included in earthquake experience equipment class	
	No possibility of detrimental differential displacement between mounting of connection head and mounting of temperature sensor	There are hundreds of temperature sensors that have gone through extremely large earthquakes without failures of any kind. Seismic interaction is evaluated under a separate caveat. This caveat should not necessary based on earthquake experience to establish reasonable confidence of seismic ruggedness.
	Associated electronics are all solid state (no vacuum tubes)	
	Attached lines have adequate flexibility	

Table B-1
Seismic RISC-3 Criteria for Replacement and New Equipment (Continued)

18) Instr. & Control Panels & Cabinets	Caveat*	Criteria for Eliminating for RISC-3
	Equipment is included in earthquake experience equipment class	
	No computers or programmable controllers	
	No strip chart recorders	
	Steel frame and sheet metal structurally adequate	
	Adjacent cabinets or panels which are close enough to impact, or sections of multi-bay cabinets or panels, are bolted together if they contain essential relays	
	Drawers and equipment on slides restrained from falling out	
	All doors secured by latch or fastener	
	Attached lines have adequate flexibility	
	Relays mounted on equipment evaluated	
19) Motor Control Centers	**Caveat***	**Criteria for Eliminating for RISC-3**
	Equipment is included in earthquake experience equipment class	
	600 V rating or less	Motor control centers of all voltage ratings have performed well in past testing and earthquakes. The caveats identified within these RISC-3 seismic guidelines have addressed all known damage and failure modes. The voltage rating is not a critical characteristic and the caveat requiring demonstration that the component fits within the earthquake experience equipment class is sufficient to establish reasonable confidence.

Table B-1
Seismic RISC-3 Criteria for Replacement and New Equipment (Continued)

19) Motor Control Centers	Caveat*	Criteria for Eliminating for RISC-3
	Adjacent cabinets which are close enough to impact, or sections of multi-bay cabinets, are bolted together if they contain essential relays	
	Attached weight (except conduit) less than about 100 lbs per cabinet assembly	This caveat is not necessary. The cabinet anchorage and load path are already evaluated as part of the RISC-3 seismic Criteria.
	Externally attached items rigidly anchored	
	General configuration similar to NEMA Standards	This caveat is not necessary. The load path and anchorage caveats address the principal concern that exists for panels. Earthquake experience for international facilities that have equipment not necessarily conforming to NEMA type enclosures have not resulted in identifying this design type to be a critical characteristic to seismic capacity.
	Cutouts in lower half less than 6 in. wide and 12 in. high	This caveat is not necessary. The cabinet anchorage and load path are already evaluated as part of the RISC-3 seismic Criteria.
	All doors secured by latch or fastener	
	Natural frequency relative to 8Hz limit considered	This caveat originated with respect to use of Method A. We are not using Method A for RISC-3 Applications and no failures have occurred in earthquake or testing experience attributed to a natural frequency below 8 Hz issue.
	Relays mounted on equipment evaluated.	

Table B-1
Seismic RISC-3 Criteria for Replacement and New Equipment (Continued)

20) Low Voltage Switchgear	Caveat*	Criteria for Eliminating for RISC-3
	Equipment is included in earthquake experience equipment class	
	600 V rating or less	Low voltage switchgear of higher than 600 voltage ratings have performed well in past testing and earthquakes. The caveats identified within these RISC-3 seismic guidelines have addressed all known damage and failure modes. The voltage rating is judged not to be a critical seismic characteristic and the caveat requiring demonstration that the component fits within the earthquake experience equipment class is sufficient to establish reasonable confidence in this area.
	Side-to-side restraint of draw-out circuit breakers is provided	
	Adjacent cabinets which are close enough to impact, or sections of multi-bay cabinets, are bolted together if they contain essential relays	
	Attached weight (except conduit) less than about 100 lbs per cabinet assembly	This caveat is not necessary. The cabinet anchorage and load path are already evaluated as part of the RISC-3 seismic Criteria.
	Externally attached items rigidly anchored	
	General configuration similar to ANSI C37.20 Standards	This caveat is not necessary. The load path and anchorage caveats address the principal concern that exists for panels. Earthquake experience for international facilities that have equipment not necessarily conforming to ANSI standards have not resulted in identifying this design type to be a critical characteristic to seismic capacity.
	Cutouts in lower half of cabinet side sheathing less than 30% of width of side panel wide and less than 60% of width of side panel high excluding bus transfer compartment	This caveat is not necessary. The cabinet anchorage and load path are already evaluated as part of the RISC-3 seismic Criteria.
	All doors secured by latch or fastener	
	Relays mounted on equipment evaluated	

C
G-STERI SEISMICALLY ADEQUATE REPLACEMENT ITEMS

The G-STERI items, as shown in Table C-1, are candidates for being considered in a RISC-3 modification of G-STERI. The items shown in Table C-1 all remain functional during and after a seismic event and do not have any bounding conditions that limit seismic demand. They may be procured and installed in a host by verifying the G-STERI specific conditions. The specific conditions for these items can be separated into 1) procurement requirements and 2) verification requirements. This sub-set of 27 items is designated as ***RISC-3 seismically adequate***. This Appendix provides the modified procurement and verification requirements for each item. Procurement requirements are simple statements of replacement item form, fit, and function as well as any material limitations (e.g., no cast iron). Verification requirements are caveats which may be verified after item installation. They are similar to SQUG GIP walkdown caveats (such as identification of any seismic interactions) and can easily be put into a walkdown check sheet form. The RISC-3 seismically adequate procedure essentially is similar to a SQUG evaluation where the replacement item is considered to be part of an existing equipment item. The item is procured and installed with reasonable confidence that it will be successfully verified as adequate. If issues are identified during the walkdown evaluation of the installed replacement item, then it would be treated similar to a SQUG outlier and the outlier condition evaluated.

The development of the G-STERI evaluations was a consensus process involving a group of knowledgeable utility procurement and equipment engineers with “hands-on” experience dealing with replacement part issues for seismically qualified equipment. The G-STERI process is a supplementary procedure to the TERI process which is intended to deal with issues of material similarity and issues concerned with form, fit, and function of the replacement part compared to the part being replaced. Many of the G-STERI requirements deal with physical attributes of the replacement part, which are important for maintaining the host qualification and seismic functional qualification. These subject requirements were originally TERI requirements that the utility group was unsure would always be included in the TERI process (e.g., small differences in part weight), thus they were re-emphasized in the G-STERI list of attributes. A certain sub-set of these attributes can be generalized to apply to all replacement items. These general attributes, as shown in Table C-2, are simple procurement or verification requirements that can be incorporated in general plant procedures to augment the plant TERI based procedures or installation procedures. If these general requirements are satisfied, then the 12 G-STERI evaluations, listed in Table C-3, are directly accommodated and the items can be procured and installed in accordance with plant procedures without unique evaluation in the same manner as G-STERI seismic insensitive items. The remaining 15 G-STERI evaluations have additional procurement requirements as indicated in Table C-4. If the general requirements of Table C-2 are satisfied along with the addition procurement requirements indicated in Table C-4, then the G-STERI evaluations are directly accommodated. The only additional effort is the inclusion of the item specific procurement requirements into the vendor procurement specifications.

Table C-1
G-STERI Seismic Rugged Evaluations Without Bounding or Limiting Conditions

Index	G-STERI Technical Evaluation	EVAL NO	Rev
1	Current Transformer	E-95011	Rev 0
2	Control Transformer	E-95012	Rev 0
3	AC/DC Motor	E-95014	Rev 0
4	Heater Element	E-95020	Rev 0
5	Disconnect Switch	E-95021	Rev 0
6	Voltage Regulator	E-95027	Rev 0
7	Voltage Suppressor	E-95028	Rev 0
8	Electrical Connector	E-95029	Rev 0
9	Pressure Regulator	I-95001	Rev 0
10	Pressure Gauge	I-95006	Rev 0
11	Instrument Valve	I-95007	Rev 0
12	Thermocouple	I-95010	Rev 1
13	RTD	I-95011	Rev 1
14	LVDT (Non-Spring-Loaded)	I-95016	Rev 0
15	Pump Impellers	M-94001	Rev 1
16	Hoses Single Line	M-94002	Rev 1
17	Gate and Globe Valve	M-95001	Rev 0
18	Check Valve	M-95002	Rev 0
19	Horizontal Pump	M-95003	Rev 0
20	Vertical Pump	M-95004	Rev 0
21	Fan	M-95005	Rev 0
22	Pressure Relief Valve (1” and below)	M-95007	Rev 0
23	Coupling Flexible	M-95012	Rev 0
34	Roller Bearing	M-95013	Rev 0
25	Steam Trap	M-95014	Rev 0
26	Damper	M-95015	Rev 0
27	Compressor	M-95016	Rev 0

Table C-2
RISC-3 General Requirements for Seismically Adequate Items

Generalized Procurement Requirements

1. The weight and eccentricity of the replacement is within 1 lb or 10% of the weight (whichever is greater) and 10% of the eccentricity of the original.
2. The item shall not incorporate relays with electromechanical contacts.
3. The item shall not incorporate cast iron as a construction material.
4. The spatial envelope of the replacement item shall be evaluated for dimensional conformance with the replaced item to eliminate any possibility of interaction with adjacent items.
5. No new soft targets (i.e., fragile items that may break when impacted) are added by the replacement item.
6. Vibration isolators, if present, shall be the same type and configuration as used in the item being replaced.

Generalized Verification Requirements

1. The location of the replacement item in the host shall be the same as that of the original.
2. The spatial envelop of the replacement item shall be evaluated for dimensional conformance with the replaced item to eliminate any possibility of interaction with adjacent items.
3. No new soft targets (i.e., fragile items that may break when impacted) are added by the replacement transformer.
4. The mounting, support and orientation for the replacement item shall be of the same configuration and strength as the original. The mounting and orientation shall meet replacement item vendor specifications, if provided. When the original qualification depends on alignment pins for anchorage, the pins must be engaged.
5. All replacement items shall be positively secured to prevent any movement. The installation of the item shall be in accordance with the manufacturer's recommendations.
6. Sufficient slack and flexibility shall be present in any attached cable or tubing to accommodate differential displacements. No rerouting of attached tubing has been required, thus, any seismic qualification of the tubing remains valid.

Table C-3
RISC-3 Seismically Adequate Items Without Additional Requirements

Index	RISC-3 Seismic Adequate	G-STERI EVAL NO	Rev
1	Current Transformer	E-95011	Rev 0
2	Disconnect Switch	E-95021	Rev 0
3	Voltage Regulator	E-95027	Rev 0
4	Voltage Suppressor	E-95028	Rev 0
5	Pressure Regulator	I-95001	Rev 0
6	Pressure Gauge	I-95006	Rev 0
7	Instrument Valve	I-95007	Rev 0
8	LVDT (Non-Spring-Loaded)	I-95016	Rev 0
9	Gate and Globe Valve	M-95001	Rev 0
10	Check Valve	M-95002	Rev 0
11	Steam Trap	M-95014	Rev 0
12	Compressor	M-95016	Rev 0

Table C-4
RISC-3 Seismically Adequate Items With Additional Procurement Requirements

Control Transformer (G-STERI Number:E-95012)

P1. The replacement transformer may have a potentially fragile fuse. It must be assured that soft targets, if any, are free from impact.

AC/DC Motors (G-STERI Number:E-95014)

P1. Mounting and frame size of the original is maintained in the replacement.

Heater Element (G-STERI Number:E-95020)

P1. Heater elements that have a change in materials, to ceramic for example, shall be evaluated on a case by case basis.

P2. New, long, cantilevered, unsupported lengths of thin, flexible elements should be specifically evaluated. The concern is that they may break at the connection between the element and the terminals.

P3. Any design features necessary to maintain heat transfer (e.g., spacers for tube bundles for immersion type heater coils) are secured to assure they retain the necessary configuration.

Electrical Connector (G-STERI Number:E-95029)

P1. Design attributes which maintain the strength of an electrical connector must be maintained:

a. Material: material type

b. Geometry, dimensions and configuration

P2. The mechanical mating characteristics for the connectors shall be the same as the original. The fit of the replacement shall be equivalent to the fit of the original (e.g., maintain pin connections, configuration, size and tolerances).

Thermocouple (G-STERI Number:I-95010)

P1. The thermocouple design and installation for the mounting of the connection head and the mounting of the thermocouple should not allow for differential displacements

Resistance Temperature Detector (RTD) (G-STERI Number:I-95011)

P1. The design and installation of a pipe or tank mounted RTD shall not allow differential displacement between the connection head and the RTD or thermowell.

Table C-4
RISC-3 Seismically Adequate Items With Additional Requirements (Continued)

Pump Impellers (G-STERI Number:M-94001)

P1. The configuration (shrouding, blade type and number, single or dual suction) of the replacement impeller shall be the same as the original.

P2. The dimensions (diameter of outlet and eye, vane angles, area between blades, and axial width) of the replacement impeller shall be the same as the original.

P3. The replacement material must provide adequate strength for operational loads.

Hoses (Metallic and Non-Metallic) Single Line (G-STERI Number:M-94002)

P1. The material (cover, reinforcement, core tube and end conditions) of the replacement hose shall be the same as the original.

P2. The configuration and size (OD, ID, wall thickness and overall length) of the replacement hose shall be the same as the original.

P3. The configuration (e.g., style, convolutions, braid, etc.) of the replacement hose shall be the same as the original

Horizontal Pump (G-STERI Number:M-95003)

P1. Thrust restraint of the shaft in both directions should exist.

P2. The adequacy of the structural load path from the piping nozzle attachments and motor attachment to the pump anchorage must be maintained. This requires equivalent strength for pump structural elements such as casing, nozzles, frames, feet, etc.

P3. If the original pump did not have thrust bearings, the replacement need not have thrust bearings. For original pumps with thrust bearings, replacement pump shall have thrust bearings.

Vertical Pump (G-STERI Number:M-95004)

P1. The adequacy of the structural load path from the piping nozzle attachments and motor attachment to the pump anchorage must be maintained. This requires equivalent strength for pump structural elements such as casing, nozzles, frames, feet, etc.

P2. The vertical pump shaft and column shall be of equal strength and length and intermediate shaft and column support shall be in the same configuration and location as the original.

Table C-4
RISC-3 Seismically Adequate Items With Additional Requirements (Continued)

Fan (G-STERI Number:M-95005)

P1. Maintain structural design load path adequacy (for example load path from frame to anchorage).

Pressure Relief Valve (1" and below) (G-STERI Number:M-95007)

P1. For pressure relief valves mounted directly to pressure vessels, the inlet nozzle material and wall thickness must meet or exceed the original.

Flexible Couplings (G-STERI Number:M-95012)

P1.Design Attributes Which Maintain the Strength of a flexible coupling must be maintained:

(a) Rated load capacity

(b) Configuration (size): method of attachment to shaft, fasteners, teeth, disks, etc.

(c) Configuration (style): this depends on the application of the flexible coupling

Roller Bearing (G-STERI Number:M-95013)

P1. Critical design attributes for a particular application of a bearing are maintained when the load rating is maintained. Therefore, the load rating of the replacement bearing shall be the same as the original.

Damper (G-STERI Number:M-95015)

P1. The section properties and material strength of the damper blades, frame and linkage must be equal to or stronger than the original.

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