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SEISMIC ASSESSMENT GUIDELINES FOR STRUCTURES, SYSTEMS, AND COMPONENTS CLASSIFIED AS RISK-INFORMED SAFETY CLASSIFICATION 3 (RISC-3) PER 10 CFR 50.69

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ABSTRACT

Licensed operating plants in the United States are currently subject to the deterministic seismic design requirements set forth in Title 10 of the Code of Federal Regulations (CFR), Part 100, Appendix A, *Seismic and Geologic Siting Criteria for Nuclear Power Plants*. Safety-related structures, systems, and components (SSCs) are required to be designed to withstand site-specific safe shutdown earthquake (SSE) and operating basis earthquake (OBE) ground motion levels, and their function is seismically qualified by either a dynamic analysis or qualification test. The level of assurance provided by testing or analysis is considered a special treatment requirement, which is to provide a high confidence (i.e., reasonable assurance) of functional performance.

The U.S. Nuclear Regulatory Commission amended its regulations in 2004 to provide an alternative approach for establishing the requirements for treatment of SSCs for nuclear power reactors using a risk-informed method of categorizing SSCs according to their safety significance. The rule amendment, 10 CFR 50.59 (2004), introduces an alternative risk-informed process to evaluate the safety significance of SSCs and establish an appropriate level of treatment requirements given their safety categorization and significance. SSCs can be binned into four Risk-Informed Safety Classification (RISC) groups. Section 50.69 removes RISC-3 SSCs (SSCs that are safety-related but low safety significance) at operating power reactors from the special treatment requirements of Appendix A to 10 CFR 100 but maintains the requirement that RISC-3 SSCs must demonstrate functionality for both the SSE and OBE motion levels. However, 50.69 (2004) permits a reduced level of assurance that provides reasonable confidence of functional performance. The Electric Power Research Institute (EPRI) has developed a set of alternative approaches to demonstrate that RISC-3 SSCs will meet (with reasonable confidence) the appropriate seismic requirements. These approaches were documented in EPRI 1011783 (2005), which is superseded by EPRI 3002026388 (2023). 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. This paper summarizes the approaches in EPRI 3002026388 to provide reasonable confidence that RISC-3 SSCs are capable of performing their required functions during and after design basis seismic events.

INTRODUCTION AND BACKGROUND

For commercial nuclear reactors in the United States, the U.S. Nuclear Regulatory Commission (USNRC) has established a set of regulatory requirements for the design of safety-related structures, systems, and components (SSCs) to ensure public health and safety. These requirements are primarily deterministic and are defined for a set of design basis events. This deterministic framework requires that SSCs important to safety be subjected to special treatment requirements to provide a high level of

confidence, also described as "reasonable assurance,"[1] that such SSCs will continue to function during and after the design basis events.

The USNRC amended these deterministic requirements in 10 CFR 50.69, *Risk-Informed Categorization and Treatment of Structures, Systems, and Components for Nuclear Power Reactors* (2004). 10 CFR 50.69 provides an alternative approach for the design of SSCs using a risk-informed approach of categorizing SSCs based on their safety significance. 10 CFR 50.69 (2004) defines four Risk-Informed Safety Classification (RISC) categories into which SSCs are classified. Figure 1 outlines how the Nuclear Energy Institute (NEI) 10 CFR 50.69 SSC Categorization Guide, NEI 00-04 (2005), can be used to categorize SSCs from a risk-informed perspective.

	Safety-Related	**Non-Safety Related**
Safety Significant	RISC-1	RISC-2
Low Safety Significant	RISC-3	RISC-4

Figure 1. 10 CFR 50.69 Risk-informed safety classification.

SSCs that are safety-related but of low safety significance, categorized as RISC-3 components, can be excluded from the scope of certain special treatment requirements as permitted by 10 CFR 50.69. Although RISC-3 SSCs have low safety significance for plant safety, maintaining RISC-3 SSCs design basis functionality contributes to the defence-in-depth approach and ensures that safety margins are maintained. 10 CFR 50.69 permits a reduced level of assurance that provides "reasonable confidence"[2] of functional performance for RISC-3 SSCs.

The Electric Power Research Institute (EPRI) developed a set of approaches to provide reasonable confidence that RISC-3 SSCs are capable of performing their required functions during and after design basis seismic events. These approaches are documented in EPRI 3002026388 (2023) and separated into two categories (Figure 2):

- Those affecting design changes and new equipment
- Those affecting replacement equipment and parts

This paper summarizes the approaches described in EPRI 3002026388 (2023).

[1]"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 (2007).
[2]"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.

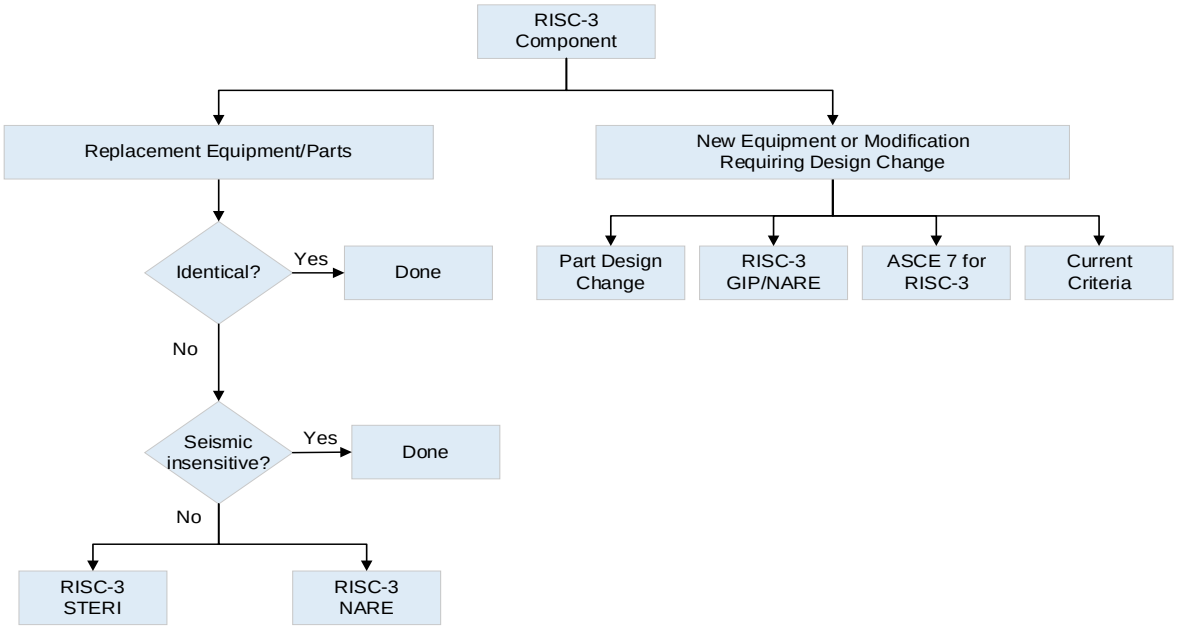

Figure 2. Seismic RISC-3 assessment flow chart.

NEW EQUIPMENT OR DESIGN CHANGE

When a RISC-3 item requires a modification that, under established plant procedures, is considered a design change, alternative approaches can be considered to provide reasonable confidence that the modified RISC-3 equipment is seismically adequate. These RISC-3 approaches include the use of:

- Seismic experience (using data from earthquake and industrial test experience)
- National building code commercial standards (e.g., ASCE 7)
- Existing plant seismic qualification procedures
- Part design change criteria (for small additions/modifications to existing RISC-3 items)

Seismic Experience – Earthquake Data

In the United States, the Unresolved Safety Issue (USI) A-46 program was developed to address the lack of explicit seismic qualification in older vintage nuclear power plants. This issue was addressed by demonstrating that nuclear plant equipment is similar to or the same as equipment used in fossil fuel power plants and heavy industrial facilities that had been subjected to strong ground motion shaking. Research on this large volume of seismic experience data, equipment shake table testing, relay seismic testing, anchorage criteria, seismic failure modes, etc., was in support of the USI A-46 resolution program. The fundamental conclusion from this large body of research is that power plant equipment can be considered generically seismically rugged if it meets a limited set of criteria. These criteria consider the characteristics of the equipment itself, the anchorage of the equipment, and the potential interaction of the equipment with adjacent SSCs.

These experience-based approaches developed in support of the USI A-46 resolution program can also be used for the qualification of RISC-3 items using a similar set of criteria:

1) Demonstration of inclusion of the item within an earthquake experience class
2) Determination that the seismic capacity of the item exceeds its seismic demand
3) Completion of engineering evaluations for the item focusing on:
   a) Anchorage evaluation and load path
   b) Interaction evaluation
   c) Critical features review

The Seismic Qualification Utility Group (SQUG) Generic Implementation Procedure (GIP) (2001) represents one of the more common sources of experience-based evaluation criteria and is generally used to establish the criteria above. However, numerous other sources can be used to develop an experience-based seismic capacity. Care should be taken when using experience data from other sources, and users should follow the approaches outlined in the source document to develop an appropriate capacity.

This experience-based approach can be utilized for both RISC-1 and RISC-3 items; however, there are several differences in the specific implementation approaches for RISC-3 SSCs. These modified RISC-3 criteria are discussed in more depth in EPRI 3002026388 (2023); an example application of this approach is provided in Appendix D to EPRI 3002026388 (2023).

Seismic Experience – Industrial Test Data

In the United States, the Department of Health Care Access and Information (HCAI) of California provides Special Seismic Certification Preapprovals (OSPs)[3] as one acceptable way to meet equipment seismic qualification requirements set forth in the California Building Code. These OSPs provide seismic certification of equipment typically used in California hospitals and ensure that the equipment's structural integrity and functionality are maintained after a design event. Shake table testing is typically performed using the criteria in International Code Council Evaluation Services (ICC-EC) AC156, *Seismic Certification by Shake-table Testing of Nonstructural Components* (International Code Council (2020)).

There are a significant number of OSPs, and they can be used to aid in the determination of the functional capacity of RISC-3 SSCs. EPRI 3002026388 (2023) recommends methods to apply the available OSP information to perform RISC-3 SSC seismic assessments and where additional approaches may be helpful to supplement the OSP data. Appendix E to EPRI 3002026388 (2023) presents an overview of the OSP qualification approach, along with an example of the information in a typical OSP.

Commercial Standards

American Society of Civil Engineers (ASCE) 7, *Minimum Design Loads for Buildings and Other Structures*, ASCE/SEI 7-22 (2022), is a commercial standard jointly developed by ASCE and the Structural Engineering Institute (SEI). ASCE 7 includes requirements for the seismic design of equipment within essential facilities with the intent of providing reasonable confidence of functional performance following an earthquake. With this level of reasonable confidence, these commercial approaches may be applied to the seismic qualification of RSIC-3 items.

The ASCE 7 provisions focus on providing seismically adequate anchorage and include functional seismic certification requirements of selected SSCs. For anchorage seismic adequacy, given the potential familiarity and efficiency of a plant engineer with RISC-1 anchorage design approaches, there may not be a significant benefit from using the ASCE equipment anchorage approach for RISC-3 SSCs. Thus, it is recommended that RISC-3 anchorage evaluations use the demand levels provided by the plant floor spectra and the plant anchorage design procedures specified for the design of RISC-1 equipment anchorages. This does not preclude the use of ASCE 7 evaluation procedures for RISC-3 SSCs, as long as they are justified to maintain the reasonable confidence that the design bases are maintained.

[3] OSP website: https://hcai.ca.gov/construction-finance/preapproval-programs/oshpd-special-seismic-certification-preapproval-osp/

For the functional assessment of RISC-3 SSCS, the ASCE 7 seismic criteria are recommended as an alternative approach with two modifications/improvements that provide the additional assurance appropriate for RISC-3 nuclear applications:

- The maximum considered earthquake (MCE) from ASCE 7 is defined as the nuclear plant site safe shutdown earthquake rather than the U.S. Geological Survey hazard mapping MCE typically used in commercial design.
- Specific functional assessments are required for relays and contactors.

Appendix A to EPRI 3002026388 (2023) provides an overview of how the ASCE/SEI 7-22 (2022) seismic design criteria can be used as an alternative design approach for RISC-3 SSCs. It details the development of seismic demand at the item location, including the development of an alternate in-structure response spectrum. Appendix A to EPRI 3002026388 (2023) also provides a discussion on the development of a generic functional screening level using the SQUG GIP (2001) Reference Spectrum and the ASCE 7-based in-structure response spectrum.

Existing Plant Procedures

Existing plant design procedures, such as those defined in the final safety analysis report, provide the seismic design basis for safety-related equipment. Additionally, many plants have modified their licensing bases to incorporate experience-based seismic qualification approaches, such as the SQUG GIP (2001) and the criteria for New and Replacement Equipment (NARE) (2000). These existing procedures are typically used to provide seismic qualification for RISC-1 items, and plant personnel are familiar with these defined methods. While the qualification of RISC-3 items specifically allows for a reduced level of effort from these RISC-1 methods, the RISC-1 methods can still be used for the qualification of RISC-3 SSCs when it is determined to be more efficient or cost-effective.

Part Design Change

Many modifications to safety-related equipment consist of the addition of an item. This is usually considered a design change, and the seismic adequacy of the entire host equipment item must be reevaluated. Most of these additions are small modifications that will likely not affect the overall function of the host equipment, although the change needs to be evaluated. For RISC-3 host equipment, the addition of small seismically insensitive items, such as a terminal block in an electrical enclosure, would not, with reasonable confidence, affect the host enclosure seismic qualification if the added component weight is limited to 10% of the total host enclosure weight. Therefore, only qualification of the added item is required, and the approach used to qualify replacement items may be used to qualify the added item.

REPLACEMENT ITEM SEISMIC QUALIFICATION

The procurement process for replacement items requires the review and identification of important design, material, and performance characteristics of the item to be replaced. Replacement items that are “like-for-like” (identical technical and physical characteristics) do not require evaluation. Replacement items that are not like-for-like are considered alternate items and must be evaluated for equivalency.

EPRI 3002026388 (2023) outlines two approaches to seismically qualify RISC-3 replacement items: the generic seismic technical evaluation of replacement items (G-STERI) (EPRI 2008a, 2008b) approach and the SQUG NARE (2000) approach.

G-STERI Approach

An equivalency evaluation provides reasonable assurance that replacement items will maintain their required seismic adequacy for their given application. EPRI developed NP-7478, *Guideline for the Seismic Technical Evaluation of Replacement Items for Nuclear Power Plants* (1993), also known as

STERI, which provides seismic equivalence evaluation guidance for replacement items for safety-related equipment. The STERI guideline is intended to provide reasonable assurance that when an equivalent replacement item is used, the original seismic qualification of both the replaced item and the host equipment is maintained. The focus of the STERI process is to maintain the seismic adequacy of equipment with existing seismic qualification in accordance with the plant's seismic design basis.

From the STERI guideline, EPRI developed generic STERI evaluations (G-STERI) in EPRI 1016691, *Plant Support Engineering: Periodic Review of G-STERI Evaluations* (2008a) and EPRI 1016694, *Plant Support Engineering: Generic Seismic Technical Evaluations of Replacement Items for Nuclear Power Plants – Item Specific Evaluations* (2008b). The G-STERI evaluations focus on item-specific evaluations of seismically insensitive and seismically rugged items that are commonly procured as replacement items for plant equipment.

The G-STERI procedures may be used to seismically qualify RISC-3 replacement items. The evaluation of RISC-3 items using the G-STERI approach are resolved in four ways:

- Like-for-Like Replacement Items: No evaluation is required.
- Seismically Insensitive Items: There is no seismic failure mechanism that can affect the seismic adequacy of the item or host. The replaced item may be procured and installed without a seismic engineering technical evaluation.
- Seismically Rugged Items: The item is generally rugged, but there are bounding conditions related to seismic demand and specific design detail restrictions that must be evaluated. Additional procurement and installation criteria must be verified.
- Potentially Seismic-Sensitive Items: The item is not considered seismically insensitive or rugged and is typically treated as a new item or as a modification requiring a new seismic qualification.

For RISC-3 applications, some simplifications of the G-STERI criteria can be applied to achieve reasonable confidence. Appendix C to EPRI 3002026388 (2023) provides the RISC-3 modified procurement and verification criteria for each item.

SQUG NARE Approach

The SQUG NARE (2000) procedures may also be used as an alternative seismic assessment method for RISC-3 items. The NARE approach generally incorporates the STERI procedures but includes supplemental verification procedures for the item replacement within the SQUG experience-based procedures.

CONCLUSION

For safety-related SSCs with low safety significance (RISC-3), EPRI 3002026388 (2023) provides guidance on appropriate methods to achieve reasonable confidence that the SSC will perform its required functions during and after design basis seismic events. Guidance is provided for replacement item applications and design change applications. The qualification methods include the use of earthquake and test experience methods from the SQUG GIP (2001), equivalency methods from G-STERI (EPRI 2008a, 2008b), commercial analysis tools from ASCE/SEI 7-22 (2022), and commercially available shake table data (HCAI OSPs).

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