## ArevaEPRDCPEm Resource

**From:** Pederson Ronda M (AREVA NP INC) [Ronda.Pederson@areva.com]
**Sent:** Friday, February 27, 2009 2:56 PM
**To:** Getachew Tesfaye
**Cc:** WELLS Russell D (AREVA NP INC); DELANO Karen V (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC)
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 161 (1876, 1830,1880), FSAR Ch. 3
**Attachments:** RAI 161 Response US EPR DC.pdf

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 161 Response US EPR DC.pdf" provides technically correct and complete responses to 27 of the 31 questions.

Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which supports the response to RAI 161 Questions 03.10-2, 03.10-5, 03.10-7, 03.10-10, 03.10-21, 03.12-11.

The following table indicates the respective pages in the response document, "RAI 161 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

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A complete answer is not provided for 4 of the 31 questions. The schedule for technically correct and complete responses to these questions is provided below.

| Question # | Response Date |
|---|---|
| RAI 161 — 03.10-17 | October 30, 2009 |
| RAI 161 — 03.10-18 | October 30, 2009 |
| RAI 161 — 03.10-19 | October 30, 2009 |
| RAI 161 — 03.10-20 | October 30, 2009 |

Sincerely,

*Ronda Pederson*

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**From:** Getachew Tesfaye [mailto:Getachew.Tesfaye@nrc.gov]
**Sent:** Wednesday, January 28, 2009 8:09 PM
**To:** ZZ-DL-A-USEPR-DL
**Cc:** Pei-Ying Chen; Kaihwa Hsu; Jennifer Dixon-Herrity; Anthony Hsia; Michael Miernicki; Joseph Colaccino; Meena Khanna; ArevaEPRDCPEm Resource
**Subject:** U.S. EPR Design Certification Application RAI No. 161 (1876, 1830,1880), FSAR Ch. 3

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on December 22, 2008, and discussed with your staff on January 13, 2009. Draft RAI Questions 03.10-1, 03.10-6(1), 03.12-3, and 03.12-6 were deleted and Draft RAI Questions 03.12-11 was modified as a result of that discussion. The schedule we have established for review of your application assumes technically correct and complete responses within 30 days of receipt of RAIs. For any RAIs that cannot be answered within 30 days, it is expected that a date for receipt of this information will be provided to the staff within the 30 day period so that the staff can assess how this information will impact the published schedule.

Thanks,
Getachew Tesfaye
Sr. Project Manager
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(301) 415-3361

**Hearing Identifier:** AREVA_EPR_DC_RAIs
**Email Number:** 266

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**Response to**

**Request for Additional Information No. 161 (1876, 1830, 1880), Revision 0**

**01/28/2009**

**U. S. EPR Standard Design Certification**
**AREVA NP Inc.**
**Docket No. 52-020**
**SRP Section: 03.10 - Seismic and Dynamic Qualification of Mechanical and Electrical Equipment**
**SRP Section: 03.12 - ASME Code Class 1, 2, and 3 Piping Systems and Piping Components and Their Associated Supports**

**Application Section: FSAR Ch 3**

**QUESTIONS for Engineering Mechanics Branch 2 (ESBWR/ABWR Projects) (EMB2)**
**QUESTIONS for Engineering Mechanics Branch 1 (AP1000/EPR Projects) (EMB1)**

**Question 03.10-2:**

In Section 3.10.1.3 of the submittal, the applicant indicates, as one acceptance criterion, that seismic qualification should demonstrate that the equipment is capable of performing its safety-related functions when subjected to normal operating loads or the maximum expected seismic loads (e.g., the SSE loads). SRP 3.10 requires that seismic qualification consider the full range of normal and accident loadings; GDC 2 states that design bases for equipment shall reflect appropriate combinations of the effects of normal and accident conditions together with the effects of natural phenomena (without loss of capability to perform their safety functions); and Section III of Appendix B to 10 CFR Part 50 indicates that a testing program shall include qualifications testing of a prototype unit under the most adverse design conditions. The staff finds that relevant sections of the applicant's submittal (e.g., Sections 3.10 and 3.9.3) do not convey a consistently appropriate treatment for combining seismic loads with loads from other accident conditions and normal operating conditions. Therefore, the applicant is requested to revise the submittal (including the noted sections) to provide a specific description of the combined load cases involving seismic, and to clearly explain how these combined load effects will be suitably addressed in seismic qualification tests and/or analyses for the various categories of mechanical and electrical equipment.

**Response to Question 03.10-2:**

The reference to "combining seismic loads with loads from other accident conditions and normal operating conditions" in the question is derived from the Technical Rationale Section of SRP 3.10 regarding compliance with GDC 1. Specifically, this SRP section states that IEEE Std 344 as endorsed by RG 1.100, Revision 2, provides guidance for establishing acceptable seismic and dynamic test (and/or evaluation) qualification and documentation criteria for electrical and mechanical equipment in nuclear power plants. Conformance with this IEEE standard and RG 1.100 is addressed in U.S. EPR FSAR Tier 2, Section 3.10.1.1. Additionally, SRP 3.10 states that SRP Section 3.9.3 defines the design and service-loading combinations for mechanical and electrical equipment including American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) Class 1, 2, and 3 components, component supports, and core support structures. U.S. EPR FSAR Tier 2, Section 3.10 identifies sections that interface with it and specifically provides a reference to U.S. EPR FSAR Tier 2, Section 3.9.3 regarding the definition of design and service-loading combinations for mechanical and electrical equipment. U.S. EPR FSAR Tier 2, Section 3.10.1.3 will be revised to add accident load conditions as part of the acceptance criteria for seismic qualification of electrical, instrumentation, and mechanical components.

**FSAR Impact:**

U.S. EPR FSAR Tier 2, Section 3.10.1.3 will be revised as described in the response and indicated on the enclosed markup.

**Question 03.10-3:**

SRP 3.10 (SRP Acceptance Criteria 6.B.ii) indicates that an FSAR should provide information on any in-plant (in-situ) tests, as well as any plans for operational tests which may be used in confirming the qualification of any item of equipment. SRP 3.10 mentions in-situ impedance testing (e.g., for systems/circuit-level testing of power distribution), however, in-situ testing is similarly applicable for other systems or elements (e.g., in-situ application of vibratory devices to simulate the seismic and dynamic vibratory motions on a complex active device; in-situ functionality testing of instrumentation and control components for simulated seismic conditions, potentially including automatic seismic SCRAM; and so forth).

Section 3.10 of the applicant's submittal does not provide such information on in-situ / operational tests (or demonstration that in-situ / operational tests are not needed to confirm the qualification for any item of equipment and/or associated system). Therefore, the applicant is requested to report on any plans for in-situ / operational tests, fully explaining the test program, its purpose, procedure, and criteria for test success. If in-situ / operational tests are not anticipated, then the applicant should fully explain and justify why such tests are not needed to confirm any qualification or basis for qualification.

**Response to Question 03.10-3:**

There are no in-plant tests, such as in situ impedance tests, which will be used to confirm the qualification of any item of equipment. After installation, active components are subjected to hydrostatic tests, construction acceptance tests, and preoperational tests and where applicable, periodic inservice inspections and operations to verify the functionality and reliability of the component.

**FSAR Impact:**

The U.S. EPR FSAR will not be changed as a result of this question.

**Question 03.10-4:**

Section 3.10 of the applicant's submittal indicates that, aside from loss of offsite power, no other extraordinary events or accidents (including LOCAs, high-energy line breaks, and other events) are postulated to occur together with the SSE. The submittal also cites NUREG-1030 and European Utility Requirements as bases for excluding consideration of the simultaneous occurrence of a LOCA with a seismic event. Such approaches are not in accordance with NRC's regulation (GDC 4). SRP 3.10 (e.g., Acceptance Criteria, Items A.xiv(2)(c,d); Technical Rationale for acceptance criteria, Item 3; and approach for staff Evaluation Findings), as well as applicable GDCs and NRC regulations, explicitly require that occurrence of a LOCA, and other appropriate accident conditions, be considered in combination with a seismic event. Therefore, the staff does not find the applicant's approach, of excluding occurrence of LOCAs and other postulated accident conditions (in combination with a SSE event), to be justified. Hence, the applicant is requested to revise Section 3.10 of the submittal to, in accordance with SRP Section 3.10 or other suitable methodology, provide a description of procedures for addressing LOCAs and other accident conditions in combination with seismic events, or alternatively, provide additional information that clearly demonstrates justifiable basis for excluding consideration of LOCAs and other appropriate accident conditions in combination with seismic events.

**Response to Question 03.10-4:**

The question states excluding consideration of the simultaneous occurrence of a loss of coolant accident (LOCA) with a seismic event is not in accordance with GDC 4. However, GDC 4 does not apply to seismic events, rather that falls under GDC 2. This is consistent with the acceptance criteria of SRP 3.10 which states "GDC 2 and Appendix S to 10 CFR Part 50 as they relate to designing equipment to withstand the effects of natural phenomena such as earthquakes," and "GDC 4 as it relates to qualifying equipment as capable of withstanding the dynamic effects associated with external missiles and internally generated missiles, pipe whip, and jet impingement forces."

NUREG-1030 addresses compliance with GDC 2 and specifically states in Section 1.3.2 regarding the scope of seismic adequacy under RG 1.29 that the seismic event does not cause a LOCA. Additionally, in GL 87-02, which also addressed conformance with GDC 2, NRC also reiterated under the scope of seismic adequacy review that a seismic event does not result in a LOCA. The question also states excluding consideration of the simultaneous occurrence of a LOCA with a seismic event is not in accordance with the guidance of SRP 3.10 (e.g., Acceptance Criteria, Items A.xiv(2)(c,d); Technical Rationale for acceptance criteria, Item 3; and approach for staff Evaluation Findings). However, SRP 3.10 Acceptance Criteria, Items A.xiv(2)(c,d) and the Technical Rationale for acceptance criteria, Item 3 only addresses LOCAs and dynamic effects (e.g., pipe whip, missiles, and discharging fluids). Additionally, Item 2 of the Technical Rationale Section of SRP 3.10 states: "SRP Section 3.10 cites guidance for testing and analysis that is acceptable to the staff for ensuring that mechanical and electrical equipment will withstand all appropriate combinations of seismic and dynamic effects caused by natural phenomena." This would exclude consideration of a seismic event concurrent with a LOCA since a LOCA is not a natural phenomenon.

AREVA NP's position on this issue is consistent with NRC guidance for both new reactors and current operating plants as discussed below.

- In DG-1145, Appendix I, “Response to Public Comments on DG-1145,” page A-31, NRC was asked the following question in Section C.I.6.2.1.1-1, “Subitems (a) and (b) then request information regarding "the postulated accident conditions and the extent of simultaneous occurrences (e.g., seismic event….” This seems to imply that a simultaneous seismic event and LOCA should be evaluated for containment analysis. Please clarify and confirm that this is NOT the intent of these statements. NRC responded that: “The NRC does not intend to formulate a new requirement. The wording will be revised to make it clearer. The intent was to say that only seismically qualified equipment should be credited for accident mitigation in containment safety analyses.”

- In designing and analyzing engineering safety features (EF) to withstand a single failure during the period of recovery following an incident, without loss of its protective function, operating plants are not required to assume that any natural or accidental event of infrequent occurrence and its related consequences that affect the plant operation and require the use of ESF system occur simultaneously with a LOCA. This is documented in operating plant FSARs (e.g., North Anna Power Station Updated Final Safety Analysis Report, Section 3.1).

- In the Millstone Power Station, Unit No. 2 License Basis Document Change Request (LBDCR) for selective implementation of the alternative source term fuel handling accident analyses, it was specifically noted in Section 6.7.4.1.2, “Single Failure Evaluation,” that “Simultaneous occurrence of a LOCA and a seismic event is not a design basis for Millstone Unit 2.” (ML023040334)

- In response to NRC questions regarding Generic Letter 96-06, South Carolina Electric & Gas Company (SCE&G) stated that the Virgil C. Summer Nuclear Station (VCSNS) design basis does not require the consideration of the seismic event occurring coincident with any other transient, such as a LOCA. (ML053490109)

**FSAR Impact:**

The U.S. EPR FSAR will not be changed as a result of this question.

**Question 03.10-5:**

In Section 3.10.1.3 of the submittal, the applicant's indication that "some" permanent deformation of component supports and structures is acceptable in seismic qualification is considered to be overly vague and potentially inconsistent with NRC's regulations and guidance. Therefore, the applicant is requested to provide additional information and to revise Section 3.10 of the submittal to explicitly clarify and justify the level, and locations/situations, of "some" permanent deformation that will be allowable according to the proposed approaches for seismic qualification testing and/or analysis. In this additional information, the applicant should specify the permissible extent and degree of inelasticity at the SSE design level for the various categories of equipment (and types of equipment supports), the criteria (or reference state) for successful performance of the equipment safety function during seismic qualification (to at least 10 percent beyond the RRS level), and the applicant's basis (whether implicit or explicit) for assuring adequate beyond-design-basis margin with respect to both inelastic capacity reserve and equipment functionality reserve.

**Response to Question 03.10-5:**

U.S. EPR FSAR Tier 2, Section 3.10.1.3 will be revised to delete the reference to permanent deformation of component supports and structures.

**FSAR Impact:**

U.S. EPR FSAR Tier 2, Section 3.10.1.3 will be revised as described in the response and indicated on the enclosed markup.

**Question 03.10-6:**

Sections 3.10 and 3.10.1.1 of the submittal indicate that the applicant plans to use versions of standards (e.g., IEEE Std 344-2004 and IEEE Std 382-2006) that are not endorsed by the NRC in SRP 3.10 for purposes of seismic qualification of equipment. Although the submittal states that the applicant maintains the option to use current NRC-endorsed versions of the standards, it does not state that the applicant actually intends to use the NRC-endorsed versions of standards (e.g., IEEE Std 344-1987). However, the staff does not consider the applicant's approach to be generally justified, and finds that additional clarification is needed in order to identify the situations, applicable to US-EPR, where material differences in approaches are expected, and to ascertain any specific conditions that may be relevant with respect to applying the non-endorsed standards for US-EPR. Hence,

(1) [Intentionally deleted.]

(2) Section 3.10.2 of the applicant's submittal indicates that the recommendations of IEEE Std 382 (2006 version) apply to qualification, by separate testing, of attached appurtenances, such as operators, limit switches, and solenoid valves.

It is noted that the testing frequency range used in IEEE 382-2006 may not be adequate for USEPR equipment. Therefore, the applicant is requested to either justify its intended use of IEEE Std 382-2006 as an appropriate basis that accords with USNRC regulations, or to alternatively cite standards and approaches that are consistent with relevant regulatory guidance. In the former case, the applicant should additionally:

a. Identify all components that are being addressed using IEEE Std 382;

b. Provide complete justification in regard to HF motions, including any caveats on use of IEEE Std 382-2006, for application to sites where site-specific design-basis motions are expected to have significant HF energy beyond what may have been considered as basis in the development of IEEE Std 382 (e.g., up to 65 Hz).

**Response to Question 03.10-6:**

a. Justification for the use of IEEE 382-2006 is provided in U.S. EPR FSAR Tier 2, Section 3.11.2.3.5. The types of component that are expected to be addressed in accordance with the guidance of IEEE Std 382-2006 are listed below:

- Electric motor-operated valve actuators.
- Solenoid-operated valves.
- Limit switches.
- Appurtenances.

b. See the response to Question 03.10-17 regarding high frequency motions.

**FSAR Impact:**

The U.S. EPR FSAR will not be changed as a result of this question.

**Question 03.10-7:**

Section 3.10 (Introduction) of the applicant's submittal identifies a number of assumptions that appear unclear or not clearly justified, and yet are cited as basis for determining the scope of equipment to be included in the seismic qualification program. These assumptions including the following:

1. The single failure criterion is applied.
2. Exclusion of the following equipment types:
   i) Equipment which could operate, but does not need to operate, and which, upon loss of offsite power, will fail in the desired position or state.
   ii) Self-actuated check valves and manual valves.

Therefore, the applicant is requested to provide clarifying information on the specific bases and justifications for these assumptions and their effects on the scope of equipment to be qualified, and to ascertain if additional components need to be included in the seismic qualification program. In so clarifying, the response should additionally address the following items in a manner that meets NRC's regulations or guidance: (a) Indicate precisely how the single failure criterion is applied, including comparison of results (for equipment scope) with application of risk-informed bases; (b) Identify the components of type 2(i) above (and their corresponding systems) that were excluded from the scope of qualification, clarify why they were excluded, and discuss how it can be known or assured without seismic qualification that they will fail in a safe position or state; (c) Identify which components of type 2(ii) were excluded from the scope of qualification, and explain on what basis they were excluded; and (d) Based on a corresponding more detailed consideration, determine which (if any) components may need to be included in the scope of equipment qualification (such determination may require an individual component-by-component assessment for the preceding excluded equipment types and/or similarly excluded equipment).

**Response to Question 03.10-7:**

1. The single-failure criterion assumption indicates that the safe shutdown list includes more than a single train (e.g., approach used for USI A-46 plants). However, this clarification is unnecessary and will be deleted from U.S. ERP FSAR Tier 2, Section 3.10.

2. These equipment types will be deleted from U.S. EPR FSAR Tier 2, Section 3.10.

**FSAR Impact:**

U.S. EPR FSAR Tier 2, Section 3.10 will be revised as described in the response and indicated on the enclosed markup.

**Question 03.10-8:**

Table 3.10-1 of the applicant's submittal includes a list of all Seismic Category I and II components in the systems screened for seismic qualification, but Section 3.10 of the submittal does not discuss potential seismic Category II/I issues in terms of influences on scope of equipment. SRP 3.10.I (Areas of Review), indicates that equipment whose failure "can prevent the satisfactory accomplishment" of any essential safety function (whether for seismic Category II/I or other reasons) should also be included in the scope of the seismic and dynamic qualification of electrical and mechanical equipment. Section 3.10 of the submittal does not provide a clear delineation and description of the items that, pertaining to the applicant's qualification program, were included, or excluded, on the basis of this requirement. Therefore, the applicant is requested to provide a list of such components, and in each case, sufficiently describe the potential situation of concern. As a result, it should be clearly demonstrated that no situation exists where failure of any Category I component could occur by means of failure of any equipment item that is outside the scope of the applicant's seismic and dynamic qualification program. In case the applicant does not have suitable information to completely report on the preceding, the applicant's response should explain and justify why the requested information is not currently available, and on what general bases the scope of the seismic qualification program was adequately developed (lending confidence that a successful and safe installation is possible) without this information. Additionally in such case, the applicant is requested to revise submittal Section 3.10 to include any relevant requirements for COL applicants.

**Response to Question 03.10-8:**

As indicated in the "Notes" section at the end of U.S. EPR FSAR Tier 2, Table 3.10.1-1, components with a designation SII are classified as Seismic Category II. As defined in U.S. EPR FSAR Tier 2, Section 3.2.1.2, "U.S. EPR SSC classified as Seismic Category II are designed to withstand SSE seismic loads without incurring a structural failure that permits deleterious interaction with any Seismic Category I SSC or that could result in injury to main control room occupants. The seismic design criteria that apply to Seismic Category II SSC are addressed in Section 3.7." Therefore, U.S. EPR FSAR Tier 2, Table 3.10.1-1 includes the scope of equipment addressed in the question.

**FSAR Impact:**

The U.S. EPR FSAR will not be changed as a result of this question.

**Question 03.10-9:**

Section 3.10.2.2 of the applicant's submittal is not explicitly consistent with SRP 3.10 in its treatment of check valves (i.e., operability being verified only by an analysis of structural integrity). Additionally, Section 3.10.2 of the submittal is potentially inconsistent in its treatment of active valves, dampers and active pumps through structural analysis and stress/deflection checks. In particular, SRP 3.10 requires that valve operators, damper mechanisms, pump motors, and similarly complex active devices must be tested for integrity and functionality. Therefore, the applicant is requested to accordingly revise Section 3.10 of its submittal to be fully consistent with SRP 3.10, and/or to provide appropriately clarifying information that justifies that the approach taken meets NRC's regulations.

**Response to Question 03.10-9:**

U.S. EPR FSAR Tier 2, Section 3.10 states that seismic qualification of mechanical, electrical, and I&C equipment is performed in accordance with IEEE Std 344, with qualification demonstrated by testing, analysis, or a combination of testing and analysis, with testing being the preferred method. The actual type of test used to establish qualification depends on numerous factors, such as type of equipment, its safety function, location, flexibility, complexity, and number of associated appurtenances. U.S. EPR FSAR Tier 2, Section 3.10.2.2, addresses the equipment in terms of the requirement to perform a mechanical operation, active function, during or following a seismic event, while accomplishing its specified safety-related functions(s). Furthermore, this equipment is seismically qualified by either testing, using the methodology stated in IEEE Std 344, and described in U.S. EPR FSAR Tier 2, Appendix 3D, Attachment F or by a combination of testing and analysis.

Active valves and dampers are qualified by a combination of analysis and testing to demonstrate operability and structural integrity. Attached appurtenances, such as operators, limit switches, and solenoid valves, may be qualified separately by testing, as recommended in IEEE Std 382 and IEEE Std 344.

**FSAR Impact:**

The U.S. EPR FSAR will not be changed as a result of this question.

**Question 03.10-10:**

The applicant's description of fractional SSE events (in subsections E.4.4, E.5, and E.5.2.3 of Attachment E to Appendix 3D of the submittal), to address low-cycle fatigue effects, contains apparent discrepancies (or perhaps a typographical mistake). For example, submittal Section 3.7 (referenced from Section 3.10) indicates that earthquake cycles included in the fatigue analysis are composed of five one-third SSE (i.e., five OBEs) events followed by one full SSE event. However, the submittal subsequently states that "a number of fractional peak cycles equivalent to the maximum peak cycles for five one-half SSE (i.e., five OBEs) events may be used in accordance with Appendix D of [IEEE Std 344-2004] when followed by one full SSE event."

As a result of problems mentioned above, the applicant's proposed approach is not clearly and adequately described. Therefore, the applicant is requested to provide a definitive, consistent, and complete statement concerning the proposed treatment of fatigue effects in the seismic qualification of electrical equipment by testing (including instrumentation and control), which accords with appropriate regulatory guidance (i.e., five one-half SSE as delineated in SECY-93-087, Section on Elimination of OBE).

**Response to Question 03.10-10:**

U.S EPR FSAR Tier 2, Appendix 3D, Attachment E, Sections E.4.4 and E.5 will be revised to specify that the fatigue analyses are composed of five one-half SSE events followed by one full SSE event. See the response to RAI 108, Supplement 1, Question 03.07.03-19 for a corresponding change to U.S. EPR FSAR Tier 2, Section 3.7.3.2.

U.S EPR FSAR Tier 2, Appendix 3D, Attachment E, Section E.5.2.3 will be revised to clarify the sine sweep and sine-beat test requirements. The sine sweep test method is used for the OBE event, which is at two-thirds of the required input motion (RIM) curve or two-thirds SSE level. The sine sweep test is followed by a sine-beat test used for the SSE event, which is at the RIM curve or full SSE level.

**FSAR Impact:**

U.S. EPR FSAR Tier 2, Appendix 3D, Attachment E, Sections E.4.4, E.5, and E.5.2.3 will be revised as described in the response and indicated on the enclosed markup.

**Question 03.10-11:**

Section 3.10.2.1.1 of the applicant's submittal indicates that alternative testing methods, such as single frequency and single-axis testing, are permissible in some cases. The staff considers that such testing methods have very limited applicability, and accordingly, the staff believes that it is important to specifically identify and consider such cases. Therefore, the applicant is requested to identify cases where such testing methods will be applied for qualification of any item of equipment, and to provide appropriately clarifying information to justify use of these limited methods, or to select more generally applicable multi-frequency and multi-axis testing methods. (Note: This RAI pertains not only to electrical equipment, but to all equipment – mechanical, electrical, I&C – included in the scope of the seismic and dynamic qualification program.)

**Response to Question 03.10-11:**

As noted in IEEE 344-2004, Section 8.6.1, "The types of motion available to best simulate the postulated seismic environment fall into two categories: single frequency and multiple frequency. The method chosen will depend upon the nature of the expected vibration environment and also somewhat on the nature of the equipment." Also, IEEE 344 states "If single-axis or biaxial tests are used to simulate the 3D environment, they should be applied in a conservative manner to account for the absence of input motion in the other orthogonal direction(s)."

As noted in U.S. EPR FSAR Tier 2, Section 3.10.2.1.1, recommended testing methods for different types and locations of equipment are described in U.S. EPR FSAR Tier 2, Appendix 3D, Attachment E. Regardless of which testing method is used, the test will conservatively simulate and envelope the required seismic motion at the location of the equipment.

**FSAR Impact:**

The U.S. EPR FSAR will not be changed as a result of this question.

**Question 03.10-12:**

Section 3.10 of the applicant's submittal does not describe a proposed approach for installation (seismic detailing) and seismic adequacy of electrical cables (e.g., power cables and instrument cables), cable connections, and cable penetrations. Therefore, the applicant is requested to describe the installation procedures and qualification test plans, including test specifications and acceptance criteria, for these items. The potential need for seismic qualification of cables and connections themselves will depend on what extent appropriate attention is given to seismic detailing and installation (e.g., to ensure sufficient flexibility that limits the stresses in these components). Correspondingly, the applicant should identify the appropriate standard of practice for installation of these components and describe the associated approach. For any case where the installation procedures alone are not demonstrated to be sufficient to conservatively eliminate the possibility of impairment of safety function of these components under seismic conditions in combination with normal operating and accident loads, then an adequate seismic qualification approach for the component should be presented. Additionally, since SRP 3.10 specifically includes electrical penetrations in the scope of seismic and dynamic qualification, the applicant's submittal should correspondingly describe the qualification (testing and/or analysis) approach for cable penetrations, which satisfies NRC's regulations.

**Response to Question 03.10-12:**

AREVA NP does not understand the regulatory basis for this question since there is no requirement or guidance to seismically qualify electrical cables. Cable connections, terminations, seals, splices, and effect of cable loads on cabinets are accounted for during environmental and seismic qualification of the equipment of which these components are a part. Environmental qualification of Class 1E electric cables and field splices is performed in accordance with IEEE Std 383. It should also be noted that containment penetrations are qualified in accordance with IEEE Std 317, while connection assemblies are qualified in accordance with IEEE Std 572.

**FSAR Impact:**

The U.S. EPR FSAR will not be changed as a result of this question.

**Question 03.10-13:**

SRP 3.10 specifies that instrumentation and control (I&C) for all in-scope equipment – as well as for Category 1 accident monitoring instrumentation as defined in Revision 2 and 3 of RG 1.97 and Type A, B, C, and D accident monitoring instrumentation as defined in Revision 4 of RG 1.97 – are to be included in the seismic and dynamic qualification program. Although Section 3.10 of the submittal notes that instrumentation and controls (I&C) equipment are included in the scope of the seismic qualification program, the submittal cites Chapter 7, Section 7.5, and Section 3.11 of the submittal for further information regarding I&C. Chapter 7 of EPR FSAR submittal indicates that the TELEPERM XS digital I&C (DI&C) system is employed for US-EPR, but does not provide adequate seismic qualification approach for the equipment.

The staff noticed that the test spectrum used for seismic qualification of the TELEPERM XS DI&C equipment appears to be inconsistent with the USEPR required seismic spectra for the equipment, in particular, the frequency range of the seismic spectra. Therefore, the applicant is requested to provide more detailed information to justify the use of single axis testing, not considering the potential coupling effects of the equipment axes, and also justify the overall seismic adequacy of the instrument and control devices in the TELEPERM XS system.

**Response to Question 03.10-13:**

U.S. EPR FSAR Tier 2, Section 3.10.2.1.1 states:

> "Multi-frequency and multi-axis testing are the preferred method of qualification, though the standard allows alternative testing methods, such as single frequency and single-axis testing. Regardless of which testing method is used, the test will conservatively simulate and envelop the required seismic motion at the location of the equipment. Recommended testing methods for different types and locations of equipment are detailed in Appendix 3D, Attachment E."

U.S. EPR FSAR Tier 2, Appendix 3D, Attachment E, Section E.5.1.1 provides information as to when single axis testing is used. Section 2.1.2.2 in the NRC Safety Evaluation Report (SER) of Topical Report, EMF-2110(NP)(A), Revision 1 (Reference 3 of U.S. EPR FSAR Tier 2, Section 7.1.3) identifies the input excitation was multiple frequency ranging from 5 to 35 Hz, and 3 axes, each staggered by 90 degrees. This method accounts for any coupling effects of equipment axes. The TXS equipment has been tested using the three axis method.

Additionally, inspections, tests, and acceptance criteria (ITAAC) are provided in Tier 1 to verify that the safety-related I&C equipment is seismically qualified (see U.S. EPR FSAR Tier 1, Sections 2.4.1, 2.4.2, 2.4.4, and 2.4.5).

**FSAR Impact:**

The U.S. EPR FSAR will not be changed as a result of this question.

**Question 03.10-14:**

DI&C generally involves a number of new and unique components and elements not previously encountered in qualification of older analog I&C. Additionally, seismic events present potentially unique challenges to DI&C systems and components. For instance, accident monitoring and control equipment that support functionality in case of a seismic event will generally include distributed networked sensors and actuators – some of which may include embedded software. In general, assurance of proper functionality of DI&C will involve requirements for digital-electronic computing hardware; digital sensors, integrated software; human interaction as regards configuration, maintenance, and intervention (e.g., potential intervention and/or recovery in case of seismic events); integrated performance of components; and other elements.

With respect to seismic qualification under SRP 3.10, Section 3.10 of the applicant's submittal does not include a sufficient delineation of the components of DI&C that will be subject to seismic qualification, nor a sufficient description of criteria, for determining successful functionality at the component level. Therefore, the applicant is requested to:

1. Provide additional information to identify DI&C components and justify their seismic qualification in sufficient detail to ensure that NRC regulations are met.
2. The applicant's response should, from the perspective of equipment functionality, define what constitutes a component of the DI&C systems for US-EPR, and identify all such DI&C components.
3. For each identified DI&C component, the applicant should provide complete specifications as to the behavioral and state parameters that define proper functionality of the component and associated success criteria for purposes of seismic qualification.
4. The applicant should also fully describe any non-hardware components / elements (whether integrated, embedded, installed, etc.) that are needed to ensure proper functionality of any DI&C component under seismic conditions, and explain/justify the testing, certification and other approaches employed in the US-EPR seismic qualification program, and/or other aspect of the US-EPR FSAR submittal, for ensuring proper safety function for these non-hardware components / elements for scenarios representative of design-basis seismic events and other postulated accident conditions.

**Response to Question 03.10-14:**

1. U.S. EPR FSAR Tier 2, Table 3.11-1 identifies digital instrumentation and controls (DI&C) equipment that will be seismically qualified. For example, U.S. EPR FSAR Tier 2, Table 3.11-1, page 3.11-84 identifies equipment for the protection system (PS) and their seismic qualification level. As shown in this table, the PS cabinets are seismically qualified which includes the DI&C components contained in the cabinets. Additionally, Inspections, tests, and acceptance criteria (ITAAC) verify that the safety-related I&C equipment is seismically qualified (see U.S. EPR FSAR Tier 1, Sections 2.4.1, 2.4.2, 2.4.4, and 2.4.5).

2. Components of the D&IC systems consist of elements such as I&C modules. As noted in the response to item 1, the cabinets that contain these components are seismically qualified.

3. As noted in item 2, the DI&C components are seismically qualified as part of the cabinets that contain these components. As part of the seismic qualification, a test plan is developed

that describes the specifications and acceptance criteria. The acceptance criteria for the ITAAC identified in the response to tem 1, includes the existence of a test report that concludes that the equipment can withstand seismic design basis loads without loss of safety function.

4. See the response to item 1.

**FSAR Impact:**

The U.S. EPR FSAR will not be changed as a result of this question.

**Question 03.10-15:**

Section 4 (last paragraph) of IEEE Std 344-1987 (the SRP 3.10 endorsed standard for seismic qualification of equipment) states: "The seismic testing, when part of an overall qualification program, should be performed in its proper sequence as indicated in IEEE Std 323-1983 and care should be taken to identify and account for significant aging mechanisms with test margins as discussed therein. Within these guidelines, it must be demonstrated that the equipment is capable of performing its safety function throughout its qualified life, including its functional operability during and/or after an SSE at the end of that qualified life."

There exist substantially unique challenges with respect to aging effects on seismic capability for DI&C, which (as justified by the IEEE guidance relevant to SRP 3.10) need to be considered and addressed. In particular, there exist a number of failure modes and aging mechanisms in safety-related electronics and associated servo-mechanical equipment, such as DI&C components, that are substantially new and different – with different aging time-frames and maintenance requirements / limitations – as compared to failure modes and aging mechanisms for other (e.g., power distribution, analog I&C) electrical equipment and for conventional mechanical equipment. These unique aging mechanisms lead to special considerations for the case of seismic events. Some examples include: physical aging effects, such as solder aging and associated brittle solder failure, electro-migration, temperature effects, humidity effects, cosmic radiation effects; as well as logical "aging" effects in non-hardware DI&C components (e.g., associated with software design, memory management, etc.) that potentially have unique impacts on the robustness of control logic under seismic events. This concern is particularly relevant to seismic qualification testing of sensor or control components that contain embedded microprocessors, software, and/or firmware.

The staff finds that the applicant's submittal does not adequately address many of these unique physical and logical failure modes and aging mechanism that can significantly increase the failure potential in the case of a seismic event, and thus need to be addressed accordingly (e.g., via testing of representatively age-accelerated hardware / software / firmware configurations) in seismic and dynamic qualification of DI&C. Therefore, the applicant is requested to provide complete explanation/justification as to how the seismic qualification test program for US-EPR will suitably demonstrate integrity and safety function for the possibly age-modified/representative status of electronic equipment, servo-mechanical equipment, non-hardware (software, firmware) components of DI&C, and similar elements. Additionally, the applicant is requested to identify any RoHS-compliant electronic components intended for application in US-EPR safety systems, and to discuss how such components will be tested in the seismic qualification program, and how they will be inspected and maintained to ensure that the actual situation of aging in deployed equipment will be less critical/severe than the seismically tested/qualified situation. In case the applicant does not intend to explicitly address such aging effects in the seismic qualification testing and/or analysis program for US-EPR, the applicant's response to this RAI should clearly and fully explain/justify how other aspects of the US-EPR FSAR submittal (in conjunction with the US-EPR seismic qualification program), will ensure proper safety function in the case of a seismic event.

**Response to Question 03.10-15:**

As noted in U.S. EPR FSAR Tier 2, Section 3.11.2.1, electrical equipment identified to be in a harsh location, as described in U.S. EPR FSAR Tier 2, Section 3.11.1.1, will be environmentally qualified by type testing or type testing and analysis using the guidance of IEEE Std 323. IEEE

Std 323 states that age conditioning “involves applying simulated in-service stresses, typically thermal, radiation, wear, and vibration, as appropriate, at magnitudes or rates that are more severe than expected in-service levels, but less severe than levels that cause aging mechanisms not present in normal service.” System qualifications are performed in accordance with the guidance of the test plans described in IEEE Std 323 that provides the steps in type testing for “worst state” qualifications where type testing is used.

The qualification process is discussed in Section 2.2.1.2 of EMF-2110(NP)(A) Revision 1 (Reference 3 of U.S. EPR FSAR Tier 2, Section 7.1.3). This section states that the basic task of the type test is the demonstration of the proper design of a piece of equipment and its correct functionality at the interfaces under worst case conditions.

**FSAR Impact:**

The U.S. EPR FSAR will not be changed as a result of this question.

**Question 03.10-16:**

Tier 1 of the applicant's submittal indicates that US-EPR includes a Seismic Monitoring System (SMS), but submittal Section 3.10 does not clarify if an automatic seismic SCRAM capability is intended as a feature or option of US-EPR (and if so, what seismic qualification approach is intended for the system). Therefore, the applicant is requested to clarify whether or not an automatic seismic SCRAM capability is included as a feature or option for US-EPR, and if it is, to provide complete information concerning the seismic qualification of the automatics seismic SCRAM systems and components. In case automatic seismic SCRAM is a feature or option for US-EPR, the applicant is requested to:

1. Identify the components of the automatic seismic SCRAM system, and provide a comprehensive discussion of the approach for seismic qualification for those components.
2. Provide the specifications for successful functionality of all components of the automatic seismic SCRAM system.
3. Provide a complete discussion of the ITAAC approach, at both the DC and COL stages, for system verification, including verification of system logic, for ensuring success of the automatic seismic SCRAM function for the range of possible seismic events.

**Response to Question 03.10-16:**

The U.S. EPR design does not include an automatic seismic SCRAM capability.

**FSAR Impact:**

The U.S. EPR FSAR will not be changed as a result of this question.

**Question 03.10-17:**

Although Section 3.7.1.1 of the applicant’s submittal indicates that the US-EPR design concept is targeted for application to CEUS sites, the applicant’s submittal does not contain adequate information about treatment of the HF seismic motions characteristic of such sites. The NRC staff has developed “Interim Staff Guidance (ISG) on Seismic Issues” that suggests related requirements for interface issues and ITAAC pertaining to HF ground-motion effects. Therefore, the applicant is requested to provide clarifying information on the proposed treatment of HF ground motions in the seismic qualification approach for US-EPR. The applicant’s response should include demonstration of compliance with SRP interface requirements as they pertain to the issue of HF ground motion analysis, and also explain the applicant’s approach for ITAAC pertaining to HF ground motion effects on qualification of equipment.

**Response to Question 03.10-17:**

This response will be provided by October 30, 2009.

**Question 03.10-18:**

Section 3.7.1 of the applicant's submittal proposes use of three control ground motions (EUR control motions) that are representative of common general safety requirements for European conditions. These motions were not developed according to any NRC regulatory guidance, and the submittal does not adequately clarify how these three control motions will be used for developing realistic input motions (representing the HF input for CEUS sites) for seismic qualification of US-EPR, in accordance with SRP 3.10. Additionally, for purposes of certification of a standard design for US-EPR, it needs to be established whether the seismic qualification testing will be done once for an enveloping of the in-structure responses and effects of all three control motions, or will be done three times to address the specific responses and effects for each of the three control motions. Therefore, the applicant is requested to fully explain, in relation to effects on motions used for seismic qualification, the applicability of the EUR control ground motions to NRC regulations, and how the three control motions of the standard design for US-EPR will be addressed in the applicant's seismic qualification program, including suitable clarification and justification of the development of input motions, or sets of input motions, at equipment mounting locations. The applicant should accordingly revise Section 3.10 of the submittal to reflect these explanations, clarifications and justifications.

**Response to Question 03.10-18:**

This response will be provided by October 30, 2009.

**Question 03.10-19:**

General comparison of design-representative site-specific spectra for relevant CEUS sites, against the design-basis ground-motion spectra for the three control motions of the proposed US-EPR standard plant design SSE (as conveyed in Section 3.7.1 of the applicant' submittal), reveals that the applicant's proposed design basis would be inadequate over a significant range of high frequencies, for many of the CEUS sites. This situation indicates that the applicant's guiding intent (stated in submittal Section 3.7.1.1) – i.e., for the certified design to be suitable for most of the potential CEUS sites – may not be realized.

According to NRC's regulations, the SSE is established based on site-specific consideration of the maximum earthquake potential considering the regional and local geology, seismology, and specific characteristics of local subsurface material. Furthermore, developing site-representative inputs for soil-structure interaction and/or structural analyses (used to determine in-structure responses) is needed in order to obtain representative input motions for purposes of equipment qualification. Correspondingly, SRP 3.10 indicates that motion inputs used for seismic qualification should be conservatively representative of the actual input motions at equipment mounting locations. Additionally, IEEE Std 344-1987 indicates that, for seismic qualification purposes, the goal of seismic simulation is to reproduce the postulated earthquake environment in a realistic manner. Developing input motions for equipment qualification that are not representative of, or demonstrably more severe in all cases than, what is actually expected for a given site, is an inadequate approach.

Accordingly, the staff finds that the applicant's submittal does not adequately demonstrate that the input motions (e.g., time histories at equipment locations) will suitably represent the character (including HF effects) of motions expected at CEUS sites. Therefore, the applicant is requested to provide complete justification demonstrating that the input motions to be used for seismic qualification of equipment will be suitably representative (or a conservatively bounding representation) of the actual design-level input motions for equipment. The applicant should revise Section 3.10 to accordingly justify the input motions to be used for equipment qualification.

**Response to Question 03.10-19:**

This response will be provided by October 30, 2009.

**Question 03.10-20:**

As suggested from preceding RAIs (No. 17 to 18), the applicant's submittal is likely to not produce suitably representative motion input, for purposes of equipment qualification, for a significant set of CEUS sites. This situation may present potentially significant implications/difficulties during the COL stage, and thereby may significantly limit the potential utility of the US-EPR design concept. Therefore, the applicant is requested to consider to re-define a seismic input basis that generally satisfies NRC's regulations and guidance for all foreseen cases of application of a US EPR standard design, or provide general criteria and procedures for use by COL applicants who may be faced with the case that the proposed US-EPR standard plant design SSE does not meet USNRC regulations and guidance (as pertaining to site-specific motions input for seismic design and seismic qualification of equipment) with respect to their proposed site(s).

**Response to Question 03.10-20:**

This response will be provided by October 30, 2009.

**Question 03.10-21:**

Section 3.10 of the applicant's submittal does not have a sufficiently detailed and complete description of the proposed approach for seismic and dynamic qualification of supports for mechanical and electrical equipment (including I&C), according to the requirements specified in SRP 3.10 subsection II.1.B. Therefore, the applicant is requested to revise Section 3.10 of the submittal to suitably address requirements for design adequacy of supports, in a manner consistent with SRP 3.10 or NRC's regulations. In the applicant's response, the methods and procedures of analysis or testing of the supports for mechanical and electrical equipment, and the procedures used to account for possible amplification of vibratory motion (amplitude and frequency content) under seismic and dynamic conditions, should be presented and reviewed. Additionally, as required by SRP 3.10, for establishing design adequacy of supports, analyses or tests should be performed for all supports of mechanical and electrical equipment to ensure their structural capability; the analytical results should include the required input motions to the mounted equipment, and the combined stresses of the support structures should be in accordance with criteria specified in SRP Section 3.9.3; and supports should be tested with equipment installed or with a dummy simulating the equivalent equipment inertial mass effects and dynamic coupling to the support. (If the equipment is installed in a non-operational mode for the support test, the response in the test at the equipment mounting location should be monitored and characterized. In such a case, equipment should be tested separately for functionality, and the actual input motion to the equipment in this test should be more conservative in amplitude and frequency content than the monitored response from the support test.)

**Response to Question 03.10-21:**

The equipment supports are rigid supports in order that the vibration induced amplification on the equipment due to the flexibility of the support is eliminated. The equipment supports are qualified by either analysis or testing. This methodology is consistent with the guidance in SRP 3.10, Section II.1.B. U.S. EPR FSAR Tier 2, Section 3.10.3 will be revised to add this information.

**FSAR Impact:**

U.S. EPR FSAR Tier 2, Section 3.10.3 will be revised as described in the response and indicated on the enclosed markup.

**Question 03.10-22:**

Section 3.10 of the applicant's submittal does not currently have a completed SQR / SQDP; however, several general items of information may be potentially available for review prior to development of a complete package. These general items may include:

- For each configuration (e.g., element, assembly, or mounting) of equipment to be qualified by separate tests and/or analyses:

  (a) Tables of the intended physical locations of the equipment, mounting/support description for the tests and/or analyses of the to-be-qualified configuration, and mounting/support description (e.g., wall, floor, pipe supported and/or other configurations) for each intended field installation.

  (b) Approximate masses (e.g., typical range) for the to-be-qualified configuration (with values for masses of supports/mounts distinctly identified).

  (c) Description of the systems and the equipment's function within the system, for which each equipment-test apply.

  (d) The general design / functional specifications for each case where the equipment-test is intended to apply.

  (e) Indication as to whether the to-be-qualified configuration pertains to the NSSS or balance of plant (BOP).

  (f) Explanation (identification and justification) of the required response spectra, test response spectra, associated damping, and time histories for testing and/or analysis.

  (g) The general criteria for demonstrating successful equipment functionality and successful structural integrity in the tests and/or analyses of each to-be-qualified configuration.

  (h) A general description of the decision, and associated deciding factors, as to whether the to-be-qualified configuration will be qualified by means of testing, analyses, or combined testing and analysis, and additionally:

    (1) If qualification will be by testing alone, explain (identify and justify) the intended test methods and procedures (e.g., multi-frequency, multi-directional), as well as other significant test conditions or parameters

    (2) If the qualification will be by analysis alone, explain (identify and justify) the intended analysis methods and assumptions, as well as why analysis alone is sufficient for qualification

    (3) If qualification is by testing and analysis, provide relevant explanations as identified in both of the preceding items

  (i) The load combinations, their bases, and the intended methods for introducing/superimposing the effects of combined loads in the tests and/or analyses

  (j) The candidate equipment vendors, equipment models, and vendor descriptions for each item of equipment that may be qualified

The DC applicant is requested to explain the evolution in status of SQR/SQDP-relevant information for the following time-frames: current status, status during the FSAR review, and status at the COL stage. In case any portion of the applicant's SQR will be available during the present FSAR review, the DC applicant is requested to inform the NRC of this information, or specify when they may be available for review in a site audit. Additionally, the applicant is requested to now provide any items of general information, as noted above, that may be available (particularly the three items indicated under Item (h) above). In case the applicant does not have general information to report concerning any requested item, the applicant's response should explain and justify why the requested general information is not currently available, and on what basis the USEPR FSAR design could be developed (lending confidence that a successful and safe installation is possible) without at least such general information.

**Response to Question 03.10-22:**

As noted in U.S. EPR FSAR Tier 2, Section 3.10.1.2, a seismic qualification data package (SQDP) is developed for each equipment (or equipment class) on the list to document the qualification results that establish the seismic capability of the equipment. A sample SQDP format is included in Attachment F to U.S. EPR FSAR Tier 2, Appendix 3D. Additionally, as noted in U.S. EPR FSAR Tier 2, Section 3.10.4, the results of seismic qualification testing and analysis, per the criteria in Section 3.10.1, Section 3.10.2, Section 3.10.3, are included in the SQDP. As noted in U.S. EPR FSAR Tier 2, Section 3.10.4, a COL applicant that references the U.S. EPR design certification will create and maintain the SQDP file during the equipment selection and procurement phase.

**FSAR Impact:**

The U.S. EPR FSAR will not be changed as a result of this question.

**Question 03.10-23:**

Section 3.10.4 of the applicant's submittal provides a very brief general description regarding updating and maintenance of plant-specific records and qualification reports. The submittal does not provide a detailed description, in accordance with SRP 3.10, which is needed to lend high confidence that an appropriate workflow and set of associated procedural methods/controls will be implemented for a successful system of managing qualification documents. Additionally, based on requirements of Appendices A and B of 10 CFR Part 50, SRP 3.10 stipulates that applicants should establish and maintain an acceptable quality assurance program for records control, including seismic qualification documents.

The staff finds that the applicant's submittal does not provide a sufficiently detailed description regarding administrative controls of the equipment qualification file, the handling of documentation, internal acceptance procedures, identification of the scope of NSSS and A/E suppliers, and the procedures for interchange of information between NSSS, A/E, equipment vendors, and testing laboratories. Therefore, the applicant is requested to provide a complete and detailed description of approaches to management of qualification documents. The detailed description should discuss procedures (e.g., document handling and acceptable, check-in/check-out), workflow, technology, documentation media and version control, document retrieval and back-up, and so forth. Association of documents with NSSS and A/E suppliers should be clearly identified, and consistency – or issues pertaining to inconsistency – in methods for interchanging information between NSSS, A/E, equipment vendors, and testing laboratories should be adequately addressed. Although the applicant has identified that updates and maintenance to records will occur as equipment is replaced, modified, further tested, or re-qualified, additional events may need to be anticipated – for example, plant configuration changes that may indirectly affect the qualification (and qualification file) for a given component (or components).

The applicant's response to this RAI should also address suitable quality assurance procedures and should describe the associated technologies to be employed (e.g., electronic database management). In case a consistent design of a formalized system for administrative controls and records management procedures cannot be specified by the applicant, the submittal should be revised to introduce an action item for each COL applicant to develop, document and implement such a system.

**Response to Question 03.10-23:**

As noted in U.S. EPR FSAR Tier 2, Section 3.10.4 and in accordance with the guidance of SRP 3.10, Acceptance Criteria 4, a COL applicant that references the U.S. EPR design certification will create and maintain the seismic qualification data package (SQDP) file during the equipment selection and procurement phase. Additionally, U.S. EPR FSAR Tier 2, Section 3.10.4 states that complete and auditable plant-specific records and reports are available and are maintained at a central location for the life of the plant. These records are controlled and maintained in accordance with the COL quality assurance program. The equipment seismic qualification file contains a list of the systems' equipment and the equipment support structures. The equipment list identifies which equipment is nuclear steam supply system (NSSS) supplied and which equipment is balance-of-plant supplied. The equipment qualification file includes qualification summary data sheets for each mechanical and electrical component of each system which summarizes the component's qualification. See U.S. EPR FSAR Tier 2, Appendix 3D, Attachment F for a sample SQDP and U.S. EPR FSAR Tier 2, Appendix 3D, Attachment A for a sample equipment qualification data package. Therefore, documentation to address the requirements of GDC 1 and 10 CFR 50, Appendix B, Criteria XVII to establish records concerning the qualification of equipment, complete, and auditable records is the responsibility of the COL holder as noted in U.S. EPR FSAR Tier 2, Table 1.8-2, item 3.10-1 (see FSAR mark-up attached to AREVA NP letter NRC:08:033, dated May 30, 2008 (Accession Number ML081560315).

**FSAR Impact:**

The U.S. EPR FSAR will not be changed as a result of this question.

**Question 03.12-1:**

In FSAR Tier 2 subsection 3.12.5.9, AREVA states that the RCS attached piping will be instrumented and monitored during first cycle of the first U.S. EPR initial plant operation to verify that the operating conditions have been considered in the design unless data from similar plant's operation demonstrates that thermal oscillation is not a concern for piping connected to the RCS.

The staff noted that this monitoring activity is not listed in Table 1.8-2 as part of the COL items. Clarify who is responsible for this activity and describe the monitoring program/methodology for confirming the integrity of the RCS attached piping.

**Response to Question 03.12-1:**

As noted in Section II.E.3 of the appendices to 10 CFR 52 and RG 1.206, Section C.III.4, COL information items are intended to identify certain matters that must be addressed in the site-specific portion of the FSAR. Since the information in the referenced FSAR section in the above question is incorporated by reference in the combined license (COL) it becomes the COL's responsibility. Therefore, no COL information item is required. Tests to confirm system integrity are addressed in U.S EPR FSAR Tier 2, Section 14.2 (see test numbers 30, 32, 33, 35, 37, 168, 186, 195, and 197) and the Technical Specifications (e.g., SR 3.4.12, SR 3.4.14).

**FSAR Impact:**

The U.S. EPR FSAR will not be changed as a result of this question.

**Question 03.12-2:**

In FSAR Tier 2 subsection 3.12.5.10.1, AREVA states that the pressurizer surge line temperatures will be monitored during the first cycle of the first U.S. EPR initial plant operation to verify that the design transients for the surge line are representative of actual plant operations unless data from a similar plant's operation determines that monitoring is not warranted. AREVA also states that the monitoring program, if required, includes temperature measurements at several locations along the pressurizer surge line and plant parameters including pressurizer temperature, pressurizer level, hot leg temperature, and reactor coolant pump status. The staff noted that this monitoring activity is not listed in Table 1.8-2 as part of the COL items. Clarify who is responsible for this activity and describe the monitoring program/methodology for confirming the pressurizer surge line integrity.

**Response to Question 03.12-2:**

See the response to Question 03.12-1.

**FSAR Impact:**

The U.S. EPR FSAR will not be changed as a result of this question.

**Question 03.12-4:**

In FSAR Tier 2 subsection 3.12.5.10.3, AREVA states that the normal spray line temperatures will be monitored during the first cycle of the first U.S. EPR initial plant operation to verify that the design transients for the normal spray are representative of actual plant operations unless data from a similar plant's operation determines that monitoring is not warranted.

The staff noted that this monitoring activity is not listed in Table 1.8-2 as part of COL items. Clarify who is responsible for this activity and describe the monitoring program/methodology for confirming the integrity of the normal spray.

**Response to Question 03.12-4:**

See the response to Question 03.12-1.

**FSAR Impact:**

The U.S. EPR FSAR will not be changed as a result of this question.

**Question 03.12-5:**

In FSAR Tier 2 subsection 3.12.5.10.4, AREVA states that the temperature of main feedwater lines will be monitored during the first cycle of the first U.S. EPR initial plant operation to verify the design transients for the main feedwater lines are representative of actual plant operations unless data from a similar plant's operation determines that monitoring is not warranted.

The staff noted that this monitoring activity is not listed in Table 1.8-2 as part of COL items. Clarify who is responsible for this activity and describe the monitoring program/methodology for confirming the main feedwater integrity.

**Response to Question 03.12-5:**

See the response to Question 03.12-1.

**FSAR Impact:**

The U.S. EPR FSAR will not be changed as a result of this question.

**Question 03.12-7:**

In FSAR Tier 2 Section 3C.4.1.3, AREVA states that under 100 percent power steady flow conditions the RCS components and piping are subjected to flow loads at locations where flow direction or flow area change. Describe the method for applying this load in analysis model and how to apply the results (stress, support load) of this loading.

**Response to Question 03.12-7:**

The 100 percent power steady state flow loads are obtained from the reactor coolant system (RCS) four loop hydraulic analysis using CRAFT2. The steady state axial hydraulic forces are transferred to the structural program by orienting the force time-histories using the post-processing program BWHIST. Once oriented and applied to the structural model of the RCS (in BWSPAN), the loads are evaluated on the piping, components and supports using principles of statics.

The steady state flow load is included in the piping, component and supports stress analysis as an applied mechanical load (see U.S. EPR FSAR Tier 2, Table 3.9.3-1 and Table 3-1 of Topical Report ANP-10264NP-A).

**FSAR Impact:**

The U.S. EPR FSAR will not be changed as a result of this question.

**Question 03.12-8:**

In FSAR Tier 2 Section 3.12.5.10.4, AREVA states that the emergency feedwater system (EFWS) is not actuated during normal or upset operation and the EFWS piping layout minimizes thermal stratification during emergency and faulted operation. This statement does not justify why thermal stratification will be minimized by EFWS piping layout. The staff request AREVA to provide detailed justification to substantiate that EFWS thermal stratification is minimized. Explain what the layout is and how the layout can minimize thermal stratification.

**Response to Question 03.12-8:**

The emergency feedwater system (EFWS) is composed of four trains that supply water to their respective steam generator, or to any other steam generator, via a common cross-connect discharge header. For each EFWS train, the water runs from a water storage pool (cold source) and is pumped toward the steam generator (hot source). During emergency and faulted plant operations, the thermal stratification in the emergency feedwater piping layout is minimized for the following reasons:

- The piping layout of the EFWS is physically independent of the main feedwater system (MFWS). The EFWS and MFWS have a separate nozzle connected to each steam generator, such that the EFWS piping is not affected when MFWS is being injected into the steam generator. Based on operating experience from previous plant designs, such a physical EFWS/MFWS separation reduces the frequency of thermal cycling and the susceptibility of thermal stratification in the EFWS nozzle.

- Each EFWS train is a continuously descending piping run (4-inch piping) from the steam generator to the pump, with a 90 degree elbow oriented downward at each steam generator downcomer nozzle. For each train, the length of the first vertical-to-horizontal elbow piping connected to each steam generator is greater than 38 Di, where Di is the I.D. of the EFWS piping. Because of the relatively long length and the relatively low steam velocities in the vicinity of the EFW nozzles, turbulent penetration does not occur in this first horizontal section upstream of the steam generator.

**FSAR Impact:**

The U.S. EPR FSAR will not be changed as a result of this question.

**Question 03.12-9:**

In FSAR Tier 2 Section 3.12.5.9, AREVA's thermal stratification discussion described the RCS non-isolable piping flow turbulent penetration without mentioning valve leakage cases. Provide approach to address BL 88-08 issues and ensure that valve leakage cases are evaluated and addressed.

**Response to Question 03.12-9:**

AREVA NP has analyzed and evaluated thermal stratification issues for reactor coolant system (RCS) non-isolable piping by considering valve leakage as discussed in BL 88-08 and the Electric Power Research Institute (EPRI) thermal management guidelines provided in EPRI Reports TR-1011955 (Reference 3 of U.S.EPR FSAR Tier 2, Section 3.12.7) and TR-103581 (Reference 4 of U.S.EPR FSAR Tier 2, Section 3.12.7).

The EPRI criteria used in the evaluation of the US EPR piping systems attached to the RCS for susceptibility to thermal stratification due to valve leakage are summarized below:

- For piping that extends vertically upward from the RCS followed by a horizontal section, a cold water source from leaking valve must exist in order to have the potential for thermal oscillations.
  - It is assumed that any single valve could leak. Sections with two or more valves in series are assumed to not create enough leakage to cause thermal oscillations.
  - There is a high pressure differential capable of forcing leakage.
  - There is a temperature difference between the fluid in the non-isolable piping section and the fluid from the leakage source.
- Sections of piping that are less than or equal to one inch nominal pipe size are not susceptible to thermal stratification.
- If a sufficient continuous flow rate exists within the RCS attached piping, thermal oscillations will not occur.
- For any un-isolable piping attached to the RCS with the first vertical-to-horizontal elbow L/Di greater than 20, thermal stratification does not occur in the branch line considered since the swirl penetration does not reach the horizontal segment of the first isolation valve or check valve. For this term, L is defined as the length from inside face of the RCS to a location on the branch pipe and Di is the branch line inside diameter.
- Piping oriented downward from the RCS followed by a horizontal section is not susceptible to thermal stratification due to valve leakage, based on operating plant experience presented in the EPRI guidelines Appendix B (Reference 3 of U.S.EPR FSAR Tier 2, Section 3.12.7).

The RCS-attached piping out to first normally-closed valve including the safety injection system/residual heat removal (SIS/RHR) lines, the normal spray lines, the pressurizer surge line, and the chemical and volume control system (CVCS) let down and charging lines have been evaluated. Of these systems, the CVCS let down and charging lines both have a non-isolable section attached to top of the RCS loops followed by a horizontal portion with a check valve. The length of the first upward vertical-to-horizontal elbow piping connected to the RCS is greater than 22 Di for the CVCS letdown and charging, where Di is the I.D. of the CVCS piping. The EPRI evaluation criterion based on the geometry (bullet point 4) indicates that thermal stratification from valve leakage will not occur in the CVCS let down and charging lines.

As documented in NRC Bulletin 88-08 (including the supplements) and EPRI Report TR-1011955, safety injection systems at operating plants (e.g., Farley, Tihange, Dampierre) have been susceptible to valve leakage-induced cyclic thermal stratification. The U.S. EPR design incorporates lessons learned from this operating experience in that the injection line (SIS/RHRS) continually rises in elevation from the check valve; therefore, it is not susceptible to valve leakage-induced cyclic thermal stratification.

Further information on thermal stratification, specifically for normal spray lines and the pressurizer surge line, is provided in U.S. EPR FSAR Tier 2, Section 3.12.5.9 and Section 3.12.5.10.

**FSAR Impact:**

The U.S. EPR FSAR will not be changed as a result of this question.

**Question 03.12-10:**

In FSAR Tier 2 Section 3.12, AREVA did not address inter-building settlement difference in piping design. Clarify if building settlement cases are considered for piping design.

**Response to Question 03.12-10:**

Building settlement cases are considered in the piping design as non-repeated anchor movement load cases. U.S. EPR FSAR Tier 2, Section 3.12.5.3 refers to Section 3.3 of ANP-10264NP-A (Reference 1 of U.S EPR FSAR Tier 2, Section 3.12.7) for the loads and load combinations used for piping design. ANP-10264NP-A, Table 3-2 and Table 3-4 include non-repeated anchor movement loads as a normal/upset loading condition.

**FSAR Impact:**

The U.S. EPR FSAR will not be changed as a result of this question.

**Question 03.12-11:**

a. In FSAR Tier 2 Section 3.9.1.2, the applicant identified the computer program used in analyses. The staff noted that CASS and EBDynamics were identified as part of sections 3.12 and Appendix 3C but were not identified in Section 3.9.1.2. The staff requests the applicant to revise Section 3.9.1.2 to include these codes for consistency.

b. In FSAR Tier 2 Section 3.12.3.6, the applicant identified the equivalent static method described in Section 4.2.3 of reference 1(ANP-10264(NP). The staff noted that the equivalent static method is described in Section 4.2.4 as ANP-10264(NP)-**A**. The staff requests the applicant to revise the section and reference.

c. In FSAR Tier 2 Section 3.7.1.2, the applicant states that the analysis of piping that uses the uniform support motion (USM) response spectrum method is performed with 5 percent damping. Table 3.7.1-1 also states that 5 percent damping is used for piping analysis. Topical report TR-10264(NP)-A does not address 5% damping. The staff requests the applicant to make appropriate revisions to resolve the difference.

**Response to Question 03.12-11:**

a. CASS and EBDYNAMICS are used only for the calculation of hydrodynamic coupling and fluid structure interaction of the RPV internals. They are not used for structural, hydraulic or stress analysis of the piping, components or supports. U.S. EPR FSAR Tier 2, Section 3.9.1.2 will be revised to indicate that information on CASS and EBDynamics is provided in Appendix 3C.

b. U.S. EPR FSAR Tier 2, Section 3.12.3.6 will be revised to change Section 4.2.3 to 4.2.4 as noted in the question. The change to Reference 1 was provided in the response to RAI 107, Question 03.06.02-5.

c. As noted in 3.4.4 of the Final Safety Evaluation Report for ANP-10264NP-A, AREVA NP agreed to use damping values provided in RG 1.61, Rev. 1 for uniform support motion response spectrum analysis, independent support motion response spectrum analysis, and time history analysis. U.S. EPR FSAR Tier 2, Section 3.7.1.2 and Table 3.7.1-1 will be revised accordingly.

**FSAR Impact:**

a. U.S. EPR FSAR Tier 2, Section 3.9.1.2 will be revised as described in the response and indicated on the enclosed markup.

b. U.S. EPR FSAR Tier 2, Section 3.12.3.6 will be revised as described in the response and indicated on the enclosed markup

c. U.S. EPR FSAR Tier 2, Section 3.7.1.2 and Table 3.7.1-1 will be revised as described in the response and indicated on the enclosed markup.

# U.S. EPR Final Safety Analysis Report Markups

Duration of Synthetic Time Histories. The minimum strong motion duration is six seconds, which meets the guideline in SRP Section 3.7.1 (Reference 6).

The maximum ground velocity (V) and the maximum ground displacement (D) are obtained from the ground velocity and displacement and time histories. The V/A and $AD/V^2$ values that are calculated using these two parameters are summarized in Table 3.7.1-4—Values of V/A and $AD/V^2$ for Synthetic Time Histories. As noted in SRP 3.7.1 (Reference 6), time histories that are computed in accordance with Option 1, Approach 2 have characteristics generally consistent with the characteristic values for the magnitude and distance of the appropriate controlling events defined for the UHRS.

The three components of synthetic time history are statistically independent of each other because the cross-correlation coefficients between them, as listed in Table 3.7.1-5—Cross-Correlation Coefficients Among Synthetic Time Histories, are well within the limit value of 0.16.

### 3.7.1.2 Percentage of Critical Damping Values

Structural systems or materials that experience seismic excitation exhibit energy dissipation through viscous damping. Viscous damping is a form of damping in which the damping force is proportional to the velocity. The mathematical modeling techniques described in Section 3.7.2 and Section 3.7.3 for elastic seismic analysis account for the damping of SSCsSSC by including terms to represent equivalent viscous modal damping as a percentage of critical damping.

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The equivalent modal damping values for SSE used in the seismic dynamic analysis of U.S. EPR Seismic Category I structures are presented in Table 3.7.1-1—Damping Values for Safe Shutdown Earthquake. The damping values are based primarily on the guidance in RG1.61, Rev. 1 and ASCE Std 43-05 (Reference 2). Piping analyzed for the U.S. EPR by either the time history method or the independent support motion response spectrum method uses 4 percent damping in accordance with RG 1.61, Revision 1. The analysis of piping that uses the uniform support motion (USM) response spectrum method is performed with five percent damping, as discussed in the AREVA NP Piping Analysis Topical Report ANP-10264 NP (Reference 9) and initial request for additional information (RAI) response (Reference 10), which is an exception to RG 1.61. Technical justification for this exception is provided in the AREVA response to RAI on the topical report (see Reference11). A damping ratio of four percent of critical is used when the USM response spectrum method is used to analyze piping systems that are susceptible to stress corrosion cracking or that contain supports that are designed to dissipate energy by yielding.

Values of critical damping in Table 3.7.1-1 for the seismic analysis of the RCS are consistent with RG 1.61. Seismic analysis of the reactor pressure vessel (RPV) Isolated

Model is by direct step-by-step integration time history analysis techniques, owing to the non-linear nature of the pressure vessel internals. As such, Rayleigh damping is applied. The Rayleigh mass and stiffness weighted damping coefficients are selected to provide generally conservative damping across the frequency range of interest relative to the values in Table 3.7.1-1. The elements representing the fuel assemblies are damped at a maximum value of 30 percent, as described in Framatome Technologies Topical Report BAW-10133NP-A (Reference 7). The same values of damping are used in the analysis for high-energy-line-break.

In-structure response spectra (ISRS) for the NI Common Basemat Structures are generated using SSE damping values rather than the OBE damping values suggested in Table 2 of RG 1.61. Because the standard plant seismic design basis (see Section 3.7.1.1) coupled with the broad range of soil cases (see Section 3.7.1.3) results in high enveloping structural loads on both the walls and floor diaphragms of the NI Common Basemat Structures it is reasonable to conclude, on an overall stress level basis, that it is appropriate to use SSE structural damping for the NI Common Basemat Structures to generate ISRS. The ISRS for the Emergency Power Generating Building and the Essential Service Water Buildings are based on OBE structural damping.

~~Test results indicate that the damping value of conduits and cable trays and their support systems increases with an increased cable fill and level of seismic excitation.~~ The damping values for conduits and cable tray systems~~s with non-flexible support systems~~ are presented in Table 3.7.1-1. Several test programs and studies have demonstrated ~~even~~that higher damping values may be utilized for certain kinds of cable trays with flexible support systems (References 2 through 5). Flexible support systems include the rod-hung and strut-hung trapeze systems, and the strut-type cantilever and braced cantilever support systems discussed in regulatory position C.3 of RG 1.61. For cable trays with flexible support systems that are similar to those tested by Bechtel-ANCO Engineers, Inc. (Reference 3) and satisfy tray loading criteria, ~~and supports that are similar to those tested,~~ the damping values in Figure 3.7.1-16—Damping Values for Cable Trays with Flexible Support Systems, ~~are~~may be used on a case-by-case basis and are limited to maximum 20 percent damping. For cable tray systems that are significantly different than those tested by Reference 3, but satisfy loading criteria, a maximum damping value of 15 percent may be used in accordance with ASCE-43-05 (Reference 2). See Appendix 3A for additional discussion on cable tray and conduit system damping.

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Heating, ventilation, and air conditioning duct systems use damping values of 10 percent for pocket-lock construction, seven percent for companion-angle construction, and four percent for welded construction. The damping values provided in Table 3.7.1-1 are applicable to time history, response spectra and equivalent static analysis procedures for structural qualification as discussed in regulatory position C.4 of RG 1.61.

## Table 3.7.1-1—Damping Values for Safe Shutdown Earthquake
Sheet 1 of 2

| Item | Percent Critical Damping, SSE [4] |
|---|---|
| Reinforced concrete structures | 7 |
| Prestressed Concrete Structures | 5 |
| Welded Steel or Bolted Steel with Friction Connections [1] | 4 |
| Bolted Steel with Bearing Connections [1] | 7 |
| Motor, Fan, and Compressor Housings | 3 |
| Pressure Vessels, Heat Exchangers, and Pump and Valve Bodies | 3 |
| Welded Instrument Racks | 3 |
| Electrical Cabinets, Panels, and Motor Control Centers (MCC) | 3 |
| Piping Systems 03.12-11 | |
| • Time history and ISM response spectrum analysis | ~~4~~ |
| • USM response spectrum analysis | See Note 2~~5 [2]~~ |
| • Systems susceptible to Stress Corrosion Cracking (SSC) | ~~4 [2]~~ |
| • Systems with supports designed to dissipate energy by yielding | ~~4 [2]~~ |
| Reactor Coolant System [6] | |
| • Component Shells | 3 |
| • Component Internals | 4 |
| • RPV Closure Head Equipment Tie Rods | 7 |
| • RCS Component Supports | 4 |
| • RCS Piping (including Surge Line) | 4 |
| • Fuel Assemblies [5] | 30 max |
| Cable trays and supports [3] | |
| • Maximum Cable Loading [A, D] | 10 |
| • Empty [B, D] | 7 |
| • Sprayed-on Fire Retardant or other cable-restraining mechanism [C] | 7 |
| • Flexible Support Systems | 20 max |
| Conduits [3] | |
| • Maximum Cable fill [A] | 7 |
| • Empty [B] | 5 |
| HVAC Duct Systems | |
| • Pocket lock | 10 |
| • Companion angle | 7 |
| • Welded | 4 |

**Table 3.7.1-1—Damping Values for Safe Shutdown Earthquake**
**Sheet 2 of 2**

| | |
|---|---|
| Metal Atmospheric Storage Tanks<br>• Impulsive Mode<br>• Sloshing mode | <br>3<br>0.5 |

**NOTES:**

1. For steel structures with a combination of different connection types, use the lowest specified damping value, or as an alternative, use a "weighted average" damping value based on the number of each type present in the structure.

03.12-11

2. As specified in RG 1.61, Revision 1 and ANP-10264NP-A.~~Piping analysis using the USM response spectrum method and meeting the limitations specified in RG 1.61 is performed with damping of five percent of critical. The applicable limitations are summarized below.~~

   A. ~~Damping of five percent of critical is used completely and consistently.~~

   B. ~~Use of the specified damping values is limited only to response spectral analyses.~~

   C. ~~When used for reconciliation or support optimization of existing designs, the effects of increased motion on existing clearances and online mounted equipment should be checked.~~

   D. ~~Damping of four percent of critical is appropriate for analyzing the dynamic response of piping systems using supports designed to dissipate energy by yielding.~~

   E. ~~Damping of four percent of critical is applicable to piping in which stress corrosion cracking has occurred, unless a case-specific evaluation is provided on a case-by-case basis.~~

3. The following clarifications, taken from RG 1.61, are applicable.

   A. Maximum cable loadings, in accordance with the plant design specification, are to be utilized in conjunction with these damping values.

   B. Spare cable tray and, initially empty, may be analyzed with zero cable load and these damping values. (Note: Reanalysis is performed when put into service.)

   C. Restraint of the free relative movement of the cables inside a tray reduces the system damping.

   D. When cable loadings of less-than maximum are specified for design calculations, justification of the selected damping value is performed on a case-by-case basis.

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- BWSPAN: Information on this computer code is provided in Section 5.1 of Reference 2 ~~and in Reference 3~~.
- BWHIST, BWSPEC, COMPAR2, CRAFT2, P91232, EBDYNAMICS, CASS, and RESPECT: Information on these computer codes is provided in Appendix 3C.
- RELAP B&W: This is an advanced system analysis computer code designed to analyze a variety of thermal-hydraulic transients in light water reactor systems. As a system code, it provides simulation capabilities for the reactor primary coolant system, secondary system, feedwater trains, control systems, and core neutronics. Special component models include pumps, valves, heat structures, electric heaters, turbines, separators, and accumulators. Code applications include the full range of safety evaluation transients, loss of coolant accidents, and operating events. The code has been benchmarked to test facility data as documented in RELAP5/MOD2-B&W – An Advanced Computer Program for Light Water Reactor LOCA and Non-LOCA Transient Analysis (Reference 4).
- S-RELAP5: Information on this computer code is provided in Section 15.0.2. S-RELAP5 evolved from the AREVA NP ANF-RELAP code. S-RELAP5 was benchmarked against a series of LOFT experiments and against ANF-RELAP simulations.
- SUPERPIPE: Information on this computer code is provided in Section 5.1 of Reference 2. ~~and in Reference 3.~~
- GTSTRUDL: Information on this computer code is provided in Section 5.1 of Reference 2.

As addressed in ~~Reference 3~~Reference 2, there are three representative calculations from the analyses for the U.S. EPR design certification to be used in the benchmark program. These calculations utilize the piping analysis codes identified in Section 5.1 of Reference 2. As noted in Reference 2, pipe stress and support analysis will be performed by a COL applicant that references the U.S. EPR design certification. A COL applicant that references the U.S. EPR design certification will either use a piping analysis program based on the computer codes described in Section 3.9.1 and Appendix 3C or will implement ~~an NRC-approved~~a U.S. EPR benchmark program using models specifically selected for the U.S. EPR.

### 3.9.1.3 Experimental Stress Analysis

No experimental stress analysis methods are used for Category I systems or components.

### 3.9.1.4 Considerations for the Evaluation of the Faulted Condition

Section 3.9.3 describes the analytical methods used to evaluate stresses for Seismic Category I systems and components subjected to faulted condition loading.

- No other extraordinary events or accidents (e.g., LOCAs, high-energy line breaks, fires, floods extreme winds, and sabotage) are postulated to occur, other than the SSE and loss of offsite power.

- ~~The single failure criterion is applied.~~

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- The equipment to be seismically qualified includes:
  - Active mechanical equipment which operates or changes state to accomplish safe shutdown as defined in the Technical Specifications.
  - Active equipment in systems which support the operation of identified safe shutdown equipment (e.g., power supplies, control systems, cooling systems, lubrication systems).
  - Instrumentation needed to confirm that the safe shutdown functions have been achieved and are being maintained.
  - Instrumentation needed to operate the safe shutdown equipment.
  - Tanks and heat exchangers used to reach and maintain safe shutdown.
  - Cable and conduit raceways which support electrical cable for the selected safe shutdown equipment (see Section 3.7.3 and Appendix 3A).
  - Instrumentation described in RG 1.97 (see Section 3.11 for additional information regarding conformance with RG 1.97).

- The following equipment types are not identified for seismic qualification:
  - ~~Equipment which could operate, but does not need to operate, and which, upon loss of power, will fail in the desired position or state. This type of equipment is defined as passive.~~
  - Passive equipment such as piping and filters (see Section 3.9.2, Appendix 3A, and U.S. EPR Piping Analysis and Pipe Support Design (Reference 3).
  - ~~Self-actuated check valves and manual valves.~~
  - Major items of equipment in the nuclear steam supply system, their supports, and components mounted on or within this equipment, such as the reactor pressure vessel, reactor fuel assemblies, reactor internals, control rods, reactor coolant pumps, steam generators, pressurizer, and reactor coolant piping (see Section 3.7.2 and Appendix 3C).
  - Radioactive waste management systems designed in accordance with RG 1.143 (see Section 3.2.1).

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### 3.10.1.2 Performance Requirements for Seismic Qualification

A seismic qualification data package (SQDP) is developed for each equipment (or equipment class) on the list to document the qualification results that establish the seismic capability of the equipment. A sample SQDP format is included in Attachment F to Appendix 3D. The SQDP includes a specification of performance requirements that establish the safety-related functions of the equipment that must be performed during and after a seismic event.

### 3.10.1.3 Acceptance Criteria

03.10-2

The seismic qualification of electrical, instrumentation, and mechanical components demonstrates that the equipment is capable of performing its safety-related functions while subjected to normal operating loads, or accident load conditions, and the maximum expected seismic loads (e.g., the SSE loads) at the location of the equipment. Non-active mechanical components are required to maintain their structural and pressure boundary integrity during and after the required seismic event. Some permanent deformation of component supports and structures is acceptable at the SSE level, provided that the deformation does not impair the ability of the component to perform its safety-related functions.

03.10-5

### 3.10.1.4 Input Motion

The basis for the required response spectra (RRS) is provided by the in-structure response spectra (ISRS) developed at the location of the equipment from the building or subsystem analysis, as described in Section 3.7. The RRS reflects the additional amplification of the ISRS due to the flexibility of the equipment supporting structure. Damping values to be used in the qualification of systems are also discussed in Section 3.7. The ISRS, at the specified damping value, provide the basis to derive a corresponding RRS at the location of the equipment. The RRS defines the minimum seismic input motion for the qualification process for the component. The seismic loads are then added to other applicable loads, such as normal and transient operating and accident loads.

The equipment RRS and other applicable loads are used to verify the qualification of the equipment and are identified and listed in the SQDP.

## 3.10.2 Methods and Procedures for Qualifying Mechanical, Electrical and I&C Equipment

The seismic qualification of mechanical, electrical, and I&C equipment is performed in accordance with the requirements of IEEE Std 344. The qualification can be demonstrated by testing, analysis, or a combination of both. The method of qualification selected is based on the applicability of the method for the size, type, complexity, and functional requirements of the equipment.

from the piping analysis at the valve extended structure. During the test, equivalent static loads are applied at the valve in the direction that would cause the highest stresses or deflections at the base of the extended structures. The design pressure in the valve is simultaneously applied to the valve during the static pull test. The valve then performs its safety-related function, while in the deflected position, within the specified operating time limits.

Motor operators are seismically qualified by testing as recommended in IEEE Std 382 and IEEE Std 344.

### 3.10.2.3 Seismic Qualification of Non-Active Mechanical Equipment

Non-active mechanical equipment is only required to maintain its structural and pressure boundary integrity during and after the seismic event. Seismic qualification by analysis, as described in Section 3.7, Section 3.9, and Appendix 3D, Attachment E, is preferred for this equipment.

The following are typical analyses that are used for qualification:

- An analysis to determine the vibratory input to a valve or pump.
- An analysis to determine the system natural frequencies and the movement of the pump or valve during the dynamic events.
- An analysis to determine the pressure differential and the impact energy on a valve disc during a LOCA or main steam line break and to verify the design adequacy of the disc.
- An analysis to verify the design adequacy of the wall thickness of valve and pump pressure-retaining components.
- An analysis to determine the natural frequencies of a pump shaft and rotor assembly to determine whether they are within the frequency range of the vibratory excitations. If the minimum natural frequency of the assembly is beyond the excitation frequencies, a static deflection analysis of the shaft is acceptable to account for dynamic effects. If the assembly natural frequencies are close to the excitation frequencies, an acceptable dynamic analysis is performed to determine the structural response of the assembly to the excitation frequencies.

These analyses are acceptable for simple and passive elements, such as valves and pump bodies, to confirm structural integrity under postulated event loadings.

## 3.10.3 Methods and Procedures for Qualifying Supports of Mechanical and Electrical Equipment and Instrumentation

The seismic qualification of equipment requires consideration of actual or installed equipment mounting. The mounting conditions and methods for the tested or analyzed equipment simulate the expected or installed conditions. ~~The flexibility of~~



03.10-21

03.10-21

~~the supporting structure is properly considered in the testing or analysis~~The equipment supports are designed as rigid supports so that the vibration induced amplification on the equipment due to the flexibility of the support is eliminated. The equipment mounting considered in the analysis or testing is identified in the SQDP.

If qualified by analysis, the critical support component stresses, and deflections if applicable, are determined and are compared to allowable levels per applicable codes and regulations (e.g., ASME Boiler and Pressure Vessel Code). If qualified by testing, the test response spectra must envelop the RRS at the mounting location of the support, over the frequency range of interest.

## 3.10.4 Test and Analysis Results and Experience Database

The results of seismic qualification testing and analysis, per the criteria in Section 3.10.1, Section 3.10.2, Section 3.10.3, are included in the corresponding SQDP (see Appendix 3D, Attachment F). A COL applicant that references the U.S. EPR design certification will create and maintain the SQDP file during the equipment selection and procurement phase. If the seismic and dynamic qualification testing is incomplete at the time of the COL application, a COL applicant that references the U.S. EPR design certification will submit an implementation program, including milestones and completion dates, for NRC review and approval prior to installation of the applicable equipment.

Complete and auditable plant-specific records and reports are available and are maintained at a central location for the life of the plant. The reports describe the qualification methods used for the equipment in sufficient detail to document compliance with the specified criteria. These records are updated and maintained current as equipment is replaced, modified, further tested, or requalified.

The equipment seismic qualification file contains a list of the systems' equipment and the equipment support structures. The equipment list identifies which equipment is NSSS supplied and which equipment is balance-of-plant supplied. The equipment qualification file includes qualification summary data sheets for each mechanical and electrical component of each system which summarizes the component's qualification. See Appendix 3D, Attachment F for a sample SQDP and Appendix 3D, Attachment A for a sample equipment qualification data package.

## 3.10.5 References

1. NUREG-1030, "Seismic Qualification of Equipment in Operating Nuclear Power Plants," U.S. Nuclear Regulatory Commission, February 1987.

2. European Utility Requirement for LWR Nuclear Power Plants, Volume 3, EPR Subset, December 1999.

### E.4.1.2 Application of Damping in Analysis

Qualification of equipment by analysis uses a math model that accurately represents its behavior. The damping value used for the RRS is based on the behavior of the equipment. The damping values used in the analysis are provided in Section 3.7.1.2 and Table 3.7.1-1, unless they are obtained from testing or otherwise justified.

### E.4.2 Interface Requirements

Seismic EQ is employed, when required, to verify the structural integrity and operability of equipment. Seismic EQ must provide reasonable assurance that equipment does not adversely interact with nearby commodities. Adequate clearance between components is provided to preclude interference from excessive equipment displacements or deformations. Excessive displacements of the equipment may also adversely impact attached cables and conduits. These displacements and deformations can be measured during a seismic test or predicted by analysis.

### E.4.3 Mounting Simulation

The mounting conditions and methods for the equipment to be tested or analyzed must simulate the expected inservice or installed conditions of the equipment. The flexibility of intermediate supporting structures must be considered in the testing or analysis of the equipment. There must be enough cable slack between the equipment and connected cable trays and conduits to prevent additional restraints from changing the dynamic response of the equipment.

### E.4.4 Simulation of Seismically Induced Fatigue

According to information provided in Sections 3.7.3, 3.10, and the definition of OBE, consideration of explicit design and qualification cases for the OBE is not a design requirement for the U.S. EPR. However, low-level seismic effects (i.e., fatigue) that might occur from the vibrations of seismic events preceding an SSE event are considered in the seismic qualification process. For qualification by testing in accordance with IEEE Std 344 (Reference 1), the requirement to simulate fatigue is included in the seismic qualification process in terms of five one-half SSE events followed by one full SSE event~~full or fractional SSE events~~ using the approach from SECY 93-087 (Reference 3) and as described in Section 3.7.3.2.

03.10-10

### Safe Shutdown Earthquake

The RRS is developed for the SSE support locations and is derived from the seismic analysis of structures. The flexibility of intermediate supporting structures is taken into account to determine the RRS. The RRS at the location of the equipment forms the design basis for the qualification of the equipment.

### E.4.6 Other Dynamic Loads

In addition to normal operating loads and seismic loads, other vibratory loads such as hydrodynamic loads, if applicable, must be evaluated for their effect on Seismic Category I equipment in accordance with IEEE Std 344 (Reference 1).

## E.5 Qualification by Test

Qualification by testing is the preferred method for EQ. As described in Section 3.10.2 and in accordance with IEEE Std 323-2003[1] (Reference 4), the overall qualification program shall be performed in its proper sequence. The test plan includes pretest functional baseline tests, environmental aging, non-seismic vibration aging (e.g., vibration from piping, pumps, and motors among others), SSE-based seismic inertia tests, and post testing inspection. Other types of vibration, such as hydrodynamic loadings, should be simulated and included with the seismic qualification. Only the seismic qualification of equipment is addressed within this section.

Many factors, including the type of equipment, its safety function, and its location (i.e., hard-mounted or line-mounted) must be considered to determine the type of test that is used to establish the seismic qualification of equipment.

Since the OBE defined in Section 3.7 is one-third of the SSE, consideration of design or qualification cases for an OBE is not a requirement for the design of the U.S. EPR, and the COL applicant is therefore not required to perform explicit response or design analyses. Qualification by testing for the U.S. EPR is only performed according to the SSE event, and the simulation of seismically induced fatigue effects from low-level seismic events preceding the SSE are specified in terms of full or fractional SSE events. In accordance with IEEE Std 344 (Reference 1), Appendix D and information included in Section 3.7.3.2, for the simulation of seismically induced fatigue effects, the SSE test is preceded by either five tests at the ~~OBE level~~one-half SSE or by a number of fractional peak cycles equivalent to the maximum peak cycles for five one-half SSE events.

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In accordance with IEEE Std 344 (Reference 1), multi-frequency testing is the preferred qualification method. It is normally used unless single frequency tests can be justified. Single frequency tests are justified when the equipment is line mounted and the seismic input motion is dominated by one frequency (see Section E.5.2). Single frequency testing is also used to determine the natural frequency of equipment. Regardless of the type of testing utilized, the TRS must envelop the RRS over the frequency range of interest at comparable levels of damping for the test input motion (see Section E.4.1.1). The peak test amplitude for each sine beat is at least that required in IEEE Std 382 (Reference 2), or the maximum g-level specified by analysis at the mounting location of the equipment.

### E.5.2.2 Resonance Testing

It is recommended that line-mounted equipment be structurally rigid. As addressed in Section E.5.4, unless otherwise justified, resonance search testing is used to determine the natural frequency of the equipment.

### E.5.2.3 Seismic Simulation Test

A seismic simulation test is required to demonstrate that the equipment can perform its design-intended safety-related function during and after the SSE event, assuming it has been preceded by lower-level seismic events that seismically age the equipment. Additional test requirements are used to simulate the effects of seismically induced aging or fatigue.

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Per IEEE Std 382 (Reference 2), the effect of OBE vibratory motion is simulated by exposing the equipment to two sinusoidal sweeps at two-thirds of the required input motion (RIM) or two-thirds SSE level in each exis followed by a single frequency sine-beat test at the full SSE level in the same axis. In the sinusoidal sweeps at OBE level, the frequency is varied from 2 Hz to 40 Hz to 2 Hz at a rate of not more than one octave per minute. The duration of each test is equal to the time required to establish full operability of the equipment in its active and inactive functions or 10 seconds, whichever is longer. The guidance to perform five OBE tests prior to SSE is accomplished by performing two sine sweeps which provide equivalent dynamic effect of five OBEs (Reference 2, Annex B and Section B.2).~~Per IEEE Std 344 (Reference 1), and as described in Section 3.7.3.2, the effect of fatigue is simulated by exposing the equipment to five sinusoidal sweeps at the OBE level followed by a single test at the full SSE level. In the sinusoidal sweeps at the OBE level, the frequency is varied from 2 Hz to 40 Hz to 2 Hz at a rate of not more than one octave per minute. The duration of each test is equal to the time required to establish full operability of the equipment in its active and inactive functions or 10 seconds, whichever is longer.~~

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The test at the full SSE level is performed using a single frequency sine-beat test, as recommended in IEEE Std 382 (Reference 2) and IEEE Std 344 (Reference 1), and by exposing the equipment to a continuous series of sine beat tests at one-third octave intervals, over the frequency range of 2 Hz to 40 Hz. The peak test amplitude for each sine beat test is at least that required by IEEE Std 382 (Reference 2), or the maximum SSE g-level specified by analysis at the mounting location of the equipment. When necessary, the equipment is tested in more than one orientation to account for various possible mounting directions. The duration of each test is at least 15 seconds or the time required for the equipment to perform its required safety function.

### E.5.2.4 Qualification of Active Valves with Extended Structures

Active valves with extended structures are qualified by testing or by a combination of testing and analysis. Attached appurtenances, such as operators, limit switches, and

### 3.12.3.6 Small Bore Piping Method

As noted in ~~AREVA NP letter NRC:07:028 dated July 13, 2007, "Response to a Request for Additional Information Regarding AREVA NP Topical Report, ANP-10264(NP)" (Reference 2~~Reference 1~~)~~, small bore piping is defined as ASME Class 1 piping that is 1 ~~in~~inch NPS and smaller and Class 2, Class 3 and QG D piping that is 2 ~~in~~inch NPS and smaller. This piping may be analyzed using response spectrum methods described in Section 4.2.2 of Reference 1 or the equivalent static method described in Section 4.2.~~3~~4 of Reference 1.

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### 3.12.3.7 Nonseismic/Seismic Interaction (II/I)

Section 4.4 of Reference 1 addresses design and analysis considerations for the interaction of non-seismic and seismic piping.

### 3.12.3.8 Seismic Category I Buried Piping

Section 3.10 of Reference 1 addresses the seismic criteria for buried piping systems.

## 3.12.4 Piping Modeling Techniques

### 3.12.4.1 Computer Codes

Section 5.1 of Reference 1 addresses the computer codes used in the analysis of safety-related piping systems (i.e., BWSPAN and SUPERPIPE). Further information on these computer codes is provided in Reference 2.

### 3.12.4.2 Dynamic Piping Model

Section 5.2 of Reference 1 addresses the dynamic piping modeling techniques. A COL applicant that references the U.S. EPR design certification will perform a review of the impact of contributing mass of supports on the piping analysis following the final support design to confirm that the mass of the support is no more than ten percent of the mass of the adjacent pipe span.

### 3.12.4.3 Piping Benchmark Program

As indicated in Section 5.3 of topical report ANP-10264NP-A~~10264(NP)~~, pipe and support stress analysis will be performed by the COL applicant that references the U.S. EPR design certification. If the COL applicant that references the U.S. EPR design certification chooses to use a piping analysis program other than those listed in Section 5.1 of the topical report, the COL applicant will implement a benchmark program using models specifically selected for the U.S. EPR.

### 3.12.4.4 Decoupling Criteria

Section 5.4.2 of Reference 1 addresses piping decoupling criteria.