U.S. NUCLEAR REGULATORY COMMISSION

DESIGN-SPECIFIC REVIEW STANDARD FOR mPOWER^{TM} iPWR DESIGN

3.7.3 SEISMIC SUBSYSTEM ANALYSIS

REVIEW RESPONSIBILITIES

Primary - Organization responsible for seismic and structural analysis reviews

Secondary - None

I. AREAS OF REVIEW

The review scope of this Design Specific Review Standard (DSRS) section (seismic subsystems) covers all seismic Category I substructures such as platforms; support frame structures; yard structures; buried piping, tunnels, and conduits; concrete dams; and atmospheric tanks. For distribution systems, including their supports (e.g., cable trays, conduit, heating, ventilating, and air conditioning (HVAC), and piping) and equipment supports, which are reviewed under NUREG-0800 Standard Review Plan (SRP) Sections 3.9.2 and 3.9.3, supplementary seismic analysis criteria are presented in this DSRS section. Intervening structural elements between these supports and building structural steel/concrete are also reviewed under this DSRS section.

The specific areas of review are as follows:

1. Seismic Analysis Methods. The information reviewed is similar to that described in subsection I.1 of DSRS Section 3.7.2 but as applied to seismic Category I subsystems.

2. Determination of Number of Earthquake Cycles. Criteria or procedures used to establish the number of earthquake cycles resulting from the seismic events and the maximum number of cycles for which applicable seismic Category I subsystems and components are designed are reviewed.

3. Procedures Used for Analytical Modeling. The information reviewed is similar to that described in subsection I.3 of DSRS Section 3.7.2 but as applied to seismic Category I subsystems.

4. Basis for Selection of Frequencies. As applicable, criteria or procedures used to separate fundamental frequencies of components and equipment from the forcing frequencies of the support structure are reviewed.

5. Analysis Procedure for Damping. The information reviewed is similar to that described in subsection I.13 of DSRS Section 3.7.2 but as applied to seismic Category I subsystems.

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6. Three Components of Earthquake Motion. The information reviewed is similar to that described in subsection I.6 of DSRS Section 3.7.2 but as applied to seismic Category I subsystems.

7. Combination of Modal Responses. The information reviewed is similar to that described in subsection I.7 of DSRS Section 3.7.2 but as applied to seismic Category I subsystems.

8. Interaction of Other Systems with Seismic Category I Systems. The information reviewed is similar to that described in subsection I.8 of DSRS Section 3.7.2 but as applied to seismic Category I subsystems.

9. Multiply-Supported Equipment and Components with Distinct Inputs. The criteria and procedures for seismic analysis of equipment and components supported at different elevations within a building and between buildings with distinct inputs are reviewed.

10. Use of Equivalent Vertical Static Factors. The information reviewed is similar to that described in subsection I.10 of DSRS Section 3.7.2 but as applied to seismic Category I subsystems.

11. Torsional Effects of Eccentric Masses. The information reviewed is similar to that described in subsection I.11 of DSRS Section 3.7.2 but as applied to seismic Category I subsystems.

12. Seismic Category I Buried Piping, Conduits, and Tunnels. For seismic Category I buried piping, conduits, tunnels, and other subsystems, the seismic criteria and methods which consider the compliance characteristics of soil media, dynamic pressures, settlement due to earthquake and differential movements at support points, penetrations, and entry points into structures provided with anchors are reviewed.

13. Methods for Seismic Analysis of Seismic Category I Concrete Dams. The analytical methods and procedures that will be used for seismic analysis of seismic Category I concrete dams are reviewed. The assumptions made, the boundary conditions used, the hydrodynamic effects considered, and the procedures by which strain-dependent material properties of foundation are incorporated in the analysis are reviewed.

14. Methods for Seismic Analysis of Above-Ground Tanks. For seismic Category I above-ground tanks, the seismic analysis criteria and methods that consider hydrodynamic forces, tank flexibility, soil-structure interaction, and other pertinent parameters are reviewed.

15. Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC). For design certification (DC) and combined license (COL) reviews, the staff reviews the applicant's proposed ITAAC associated with the structures, systems, and components (SSCs) (if any are identified related to this DSRS section) in accordance with SRP Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." The staff recognizes that the review of ITAAC cannot be completed until after the rest of this portion of the application has been reviewed against acceptance criteria contained in this DSRS section. Furthermore, the staff reviews the ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP Section 14.3.

16. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action items and requirements and restrictions (e.g., interface requirements and site parameters).

    For a COL application referencing a DC, a COL applicant must address COL action items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

Review Interfaces

Other SRP and DSRS sections interface with this section as follows:

1. Review of geological and seismological information to establish the free-field ground motion over the complete depth of the embedded facility is performed under SRP Sections 2.5.1 through 2.5.3.

2. The geotechnical parameters and methods employed in the analysis of free field soil media and the soil properties are reviewed under SRP section 2.5.4.

3. The development of the design earthquake ground motion (response spectra and time histories) is reviewed under DSRS Section 3.7.1.

4. The seismic system analysis, which includes the seismic soil-structure interaction analysis, is reviewed under DSRS Section 3.7.2.

5. The design of seismic Category I structures for all applicable load combinations is reviewed under DSRS Sections 3.8.2 through 3.8.5.

6. For DC applications and COL applications referencing a DC rule or DC application, review of the site parameters in the Design Control Document (DCD) Tier 1 and Chapter 2 of the DCD Tier 2[1] submitted by the applicant is performed under SRP Section 2.0, "Site Characteristics/Site Parameters."

7. Review of the Probabilistic Risk Assessment is performed under SRP Section 19.0 in conjunction with DC/COL-ISG-020, "Interim Staff Guidance on Implementation of a Probabilistic Risk Assessment-Based Seismic Margin Analysis for New Reactors," for potential risk significance of SSCs and the risk-based susceptibility of risk significant SSCs to failure due to seismic hazards.

II. ACCEPTANCE CRITERIA

Requirements

Acceptance criteria are based on meeting the relevant requirements of the following Commission regulations:

1. Title 10 of the *Code of Federal Regulations* (CFR), Part 50, General Design Criterion (GDC) 2 - In relevant part, the design basis shall reflect appropriate consideration of the

[1] Additional supporting information of prior DC rules may be found in DCD Tier 2 Section 14.3.

most severe earthquakes reported to have affected the site and surrounding area with sufficient margin for the limited accuracy, quantity, and period of time in which historical data have been accumulated.

2. 10 CFR Part 50, Appendix S, is applicable to applications for a design certification or combined license to 10 CFR Part 52 or a construction permit or operating license pursuant to 10 CFR Part 50 on or after January 10, 1997. Appendix S requires that for safe shutdown earthquake (SSE) ground motions, certain SSCs will remain functional and within applicable stress, strain, and deformation limits. The required safety functions of these SSCs must be assured during and after the vibratory ground motion through design, testing, or qualification methods. The evaluation must take into account soil-structure interaction effects and the expected duration of the vibratory motion. If the operating basis earthquake (OBE) is set at one-third or less of the SSE, an explicit response or design analysis is not required. If the OBE is set at a value greater than one-third of the SSE, an analysis and design must be performed to demonstrate that when subjected to the effects of the OBE in combination with normal operating loads, all SSCs of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public must remain functional and within applicable stress, strain, and deformation limits.

3. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed inspections, tests, analyses, and acceptance criteria (ITAAC) that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a facility that incorporates the design certification has been constructed and will be operated in conformity with the design certification, the provisions of the Atomic Energy Act (AEA), and the Nuclear Regulatory Commission's (NRC's) regulations.

4. 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the combined license, the provisions of the AEA, and the NRC's regulations.

DSRS Acceptance Criteria

Specific DSRS acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are as follows for review described in this DSRS section. The DSRS is not a substitute for the NRC's regulations, and compliance with it is not required. Identifying the differences between this DSRS section and the design features, analytical techniques, and procedural measures proposed for the facility, and discussing how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria, is sufficient to meet the intent of 10 CFR 52.47(a)(9), "Contents of applications; technical information."

1. Seismic Analysis Methods. The acceptance criteria provided in DSRS Section 3.7.2, subsection II.1, are applicable.

2. Determination of Number of Earthquake Cycles. During the plant life at least one SSE and five OBEs, if applicable, should be assumed. The number of cycles per earthquake should be obtained from the time history used for the system analysis, or a minimum of 10 maximum stress cycles per earthquake may be assumed.

   When the OBE is defined as less than one-third the SSE (and therefore the OBE does not need to be considered in design), there may be certain structural elements which still need to be evaluated for fatigue due to the OBE induced stress cycles. In these instances, the guidance for determining the number of earthquake cycles for use in fatigue calculations should be the same as the guidance provided in SRM for SECY-93-087 dated July 21, 1993 for piping systems (Agencywide Document Access and Management System (ADAMS) Accession Number ML003708056). The number of earthquake cycles to consider is two SSE events with 10 maximum stress cycles per event. This is considered to be equivalent to the cyclic load basis of one SSE and five OBEs. Alternatively, the number of fractional vibratory cycles equivalent to that of 20 full SSE vibratory cycles may be used (but with an amplitude not less than one-third of the maximum SSE amplitude) when derived in accordance with Institute of Electrical and Electronics Engineers (IEEE) Standard 344-1987, Appendix D.

3. Procedures Used for Analytical Modeling. The acceptance criteria provided in DSRS Section 3.7.2, subsection II.3, are applicable.

4. Basis for Selection of Frequencies. To avoid resonance, the fundamental frequencies of components and equipment should preferably be selected to be less than one-half or more than twice the dominant frequencies of the support structure. Use of equipment frequencies within this range is acceptable if the equipment is adequately designed for the applicable loads.

5. Analysis Procedure for Damping. The acceptance criteria provided in DSRS Section 3.7.2, subsection II.13, are applicable.

6. Three Components of Earthquake Motion. The acceptance criteria provided in DSRS Section 3.7.2, subsection II.6, are applicable.

7. Combination of Modal Responses. The acceptance criteria provided in DSRS Section 3.7.2, subsection II.7, are applicable.

8. Interaction of Other Systems with Seismic Category I Systems. To be acceptable, each non-seismic Category I system should be designed to be isolated from any seismic Category I system by either a constraint or barrier, or should be remotely located with regard to the seismic Category I system. If this is not feasible or practical, then adjacent non-seismic Category I systems should be analyzed according to the same seismic criteria as applicable to the seismic Category I system. For non-seismic Category I systems attached to seismic Category I systems, the dynamic effects of the non-seismic Category I systems should be simulated in the modeling of the seismic Category I system. The attached non-seismic Category I systems, up to the first anchor beyond the interface, should also be designed in such a manner that during an earthquake of SSE intensity it will not cause a failure of the seismic Category I system.

9. Multiply-Supported Equipment and Components with Distinct Inputs. Equipment and components in some cases are supported at several points by either a single structure

or two separate structures. The motions of the primary structure or structures at each of the support points may be quite different.

A conservative and acceptable approach for analyzing equipment items supported at two or more locations is to define a uniform response spectrum (URS) that envelopes all of the individual response spectra at the various support locations. The URS is applied at all locations to calculate the maximum inertial responses of the equipment. This is referred to as the uniform support motion (USM) method. In addition, the relative displacements at the support points should be considered. Conventional static analysis procedures are acceptable for this purpose. The maximum relative support displacements can be obtained from the building structural response calculations. The support displacements can then be imposed on the supported equipment in the most unfavorable combination. The responses due to the inertia effect and relative displacements should be combined by the absolute sum method.

The URS method described above can result in considerable overestimation of seismic responses. In the case of multiply- supported equipment in a single structure and/or spanning between structures, an alternate method that can be used is the independent support motion (ISM) approach. Guidance and criteria for the use of the ISM method is given in NUREG-1061, Volume 4, Section 2. If the ISM method is utilized, all of the criteria presented in NUREG-1061 related to the ISM method must be followed.

In lieu of the response spectrum approach, time histories of support motions may be used as input excitations to the subsystems. The staff expects the time history approach to provide more realistic results than the USM or ISM methods.

10. Use of Equivalent Vertical Static Factors. The acceptance criteria provided in DSRS Section 3.7.2, subsection II.10, are applicable.

11. Torsional Effects of Eccentric Masses. For seismic Category I subsystems, when the torsional effect of an eccentric mass is judged to be significant, the eccentric mass and its eccentricity should be included in the mathematical model. The criteria for judging the significance will be determined on a case-by-case basis.

12. Seismic Category I Buried Piping, Conduits, and Tunnels. For seismic Category I buried piping, conduits, tunnels, and any other subsystems, the following items should be considered in the analysis:

    A. Two types of ground shaking-induced loadings must be considered in the design analysis.

        i. Relative deformations imposed by seismic waves traveling through the surrounding soil or by differential deformations between the soil and anchor points. The definition of the seismic wave field should consider variation over the depth of the embedded structure.

        ii. Lateral earth pressures and ground-water effects acting on structures.

    B. The effects of static resistance of the surrounding soil on piping deformations or displacements, differential movements of piping anchors, bent geometry and curvature changes, etc., should be adequately considered. Procedures using the principles of the theory of structures on elastic foundations are acceptable.

C. When applicable, the effects due to local soil settlements, soil arching, etc., should also be considered in the analysis.

D. Actual methods used for determining the design parameters associated with seismically induced transient relative deformations are reviewed and accepted on a case-by-case basis. Additional information, for guidance purposes only, can be found in NUREG/CR-1161, page 26; in American Society of Civil Engineers (ASCE) Standard 4-98, Section 3.5.2; and in the ASCE Report, "Seismic Response of Buried Pipes and Structural Components."

13. Methods for Seismic Analysis of Seismic Category I Concrete Dams. For the analysis of all seismic Category I concrete dams, an appropriate approach that takes into consideration the dynamic nature of forces (due to both horizontal and vertical earthquake loadings), the behavior of the dam material under earthquake loadings, soil-structure interaction (SSI) effects, and nonlinear stress-strain relations for the soil, should be used. Analysis of earthen dams is reviewed under SRP Section 2.5.5, "Stability of Slopes."

14. Methods for Seismic Analysis of Above-Ground Tanks. Most above-ground fluid-containing vertical tanks do not warrant sophisticated, finite element, fluid-structure interaction analyses for seismic loading. However, the commonly used alternative of analyzing such tanks by the "Housner-method" described in TID-7024 may be inadequate in some cases. The major problem is that direct application of this method relies on the assumption that the combined fluid-tank system in the horizontal impulsive mode is sufficiently rigid to justify the assumption of a rigid tank. For flat-bottomed tanks mounted directly on their bases, or tanks with very stiff skirt supports, the assumption leads to the usage of a spectral acceleration equal to the zero-period base acceleration. Studies by Veletsos (1974 and 1984), Veletsos and Yang (1977), Veletsos and Tang (1989), and Haroun and Housner (1981), have shown that for typical tank designs, the frequency for this fundamental horizontal impulsive mode of the tank shell and contained fluid is such that the spectral acceleration may be significantly greater than the zero-period acceleration. Thus, the assumption of a rigid tank could lead to inadequate design loadings. The SSI effects may also be very important for tank responses, and they may need to be considered for both horizontal and vertical motions.

The acceptance criteria below are based upon the information contained in TID-7024 and NUREG/CR-1161. Additional guidance is provided in ASCE Standard 4-98, Section 3.5.4. These references also contain acceptable calculation techniques for the implementation of these criteria. The use of other approaches meeting the intent of these criteria can also be considered if adequate justification is provided.

A. A minimum acceptable analysis must incorporate at least two horizontal modes of combined fluid-tank vibration and at least one vertical mode of fluid vibration. The horizontal response analysis must include at least one impulsive mode in which the response of the tank shell and roof are coupled together with the portion of the fluid contents that moves in unison with the shell. In addition, the fundamental sloshing (convective) mode of the fluid must be included in the horizontal analysis.

B. The fundamental natural horizontal impulsive mode of vibration of the fluid-tank system must be estimated giving due consideration to the flexibility of the supporting medium and to any uplifting tendencies for the tank. It is unacceptable to assume a rigid tank unless the assumption can be justified. The horizontal impulsive-mode spectral acceleration, S_{a1}, is then determined using this frequency and the appropriate damping for the fluid-tank system. Alternatively, the maximum spectral acceleration corresponding to the relevant damping may be used.

C. Damping values used to determine the spectral acceleration in the impulsive mode must be based upon the system damping associated with the tank shell material as well as with the SSI, as specified in NUREG/CR-1161 and Veletsos and Tang (1989).

D. In determining the spectral acceleration in the horizontal convective mode, S_{a2}, the fluid damping ratio must be 0.5 percent of critical damping unless a higher value can be substantiated by experimental results.

E. The maximum overturning moment, M_o, at the base of the tank should be obtained by the modal and spatial combination methods discussed in subsection II of DSRS Section 3.7.2. The uplift tension resulting from M_o must be resisted either by tying the tank to the foundation with anchor bolts, etc., or by mobilizing enough fluid weight on a thickened base skirt plate. The latter method of resisting M_o must be shown to be conservative.

F. The seismically induced hydrodynamic pressures on the tank shell at any level can be determined by the modal and spatial combination methods in DSRS Section 3.7.2. The maximum hoop forces in the tank wall must be evaluated with due regard for the contribution of the vertical component of ground shaking. The effects of soil-structure interaction should be considered in this evaluation unless justified otherwise. The hydrodynamic pressure at any level must be added to the hydrostatic pressure at that level to determine the hoop tension in the tank shell.

G. Either the tank top head must be located at an elevation higher than the slosh height above the top of the fluid or else must be designed for pressures resulting from fluid sloshing against this head.

H. At the point of attachment, the tank shell must be designed to withstand the seismic forces imposed by the attached piping. An appropriate analysis must be performed to verify this design.

I. The tank foundation (see also DSRS Section 3.8.5) must be designed to accommodate the seismic forces imposed on it. These forces include the hydrodynamic fluid pressures imposed on the base of the tank as well as the tank shell longitudinal compressive and tensile forces resulting from M_o.

J. In addition to the above, the tank should be designed to not allow buckling of tank walls and roof, failure of connecting piping, and sliding of the tank.

Technical Rationale:

The technical rationale for application of these acceptance criteria to the areas of review addressed by this DSRS section is discussed in the following paragraphs:

1. 10 CFR Part 50, Appendix A, GDC 2 requires, in the relevant parts, that SSCs important to safety be designed to withstand the effects of natural phenomena such as earthquakes, without loss of capability to perform their intended safety functions. GDC 2 further requires that the design bases reflect appropriate consideration for the most severe natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated in the past.

   DSRS Section 3.7.3 describes acceptable methods for the seismic analysis of seismic Category I subsystems such as platforms; support frame structures; yard structures; buried piping, tunnels, and conduits; concrete dams; and atmospheric tanks. Criteria are provided for the static and dynamic analysis of these subsystems subjected to earthquake loadings. These criteria include acceptable methods/procedures for analytical modeling, selection of damping, determination of the number of earthquake cycles, interaction of other systems with seismic Category I systems, and evaluation of multiply-supported equipment.

   Meeting these requirements provides assurance that seismic Category I subsystems will be adequately designed to withstand the effects of earthquakes, and thus, will be able to perform their intended safety functions.

2. 10 CFR Part 50, Appendix S is applicable to applications for a design certification or combined license to 10 CFR Part 52 or a construction permit or operating license pursuant to 10 CFR Part 50 on or after January 10, 1997. For SSE ground motions, 10 CFR Part 50, Appendix S requires that certain SSCs will remain functional and within applicable stress, strain, and deformation limits. The required safety functions of these SSCs must be assured during and after the vibratory ground motion through design, testing, or qualification methods. The evaluation must take into account soil-structure interaction effects and the expected duration of the vibratory motion. If the OBE is set at one-third or less of the SSE, an explicit response or design analysis is not required. If the OBE is set at a value greater than one-third of the SSE, an analysis and design must be performed to demonstrate that when subjected to the effects of the OBE in combination with normal operating loads, all SSCs of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public must remain functional and within the applicable stress, strain, and deformation limits are satisfied.

   DSRS Section 3.7.3 describes acceptable analytical methods that are used to determine the seismic response of subsystems in terms of stresses, strains, and deformations. These responses are combined with the structural responses from other loads in accordance with the criteria in DSRS Section 3.8. The criteria in DSRS Section 3.7.3 ensure that the effects of soil-structure interaction and expected duration of the earthquake are appropriately included in the evaluation. In addition, criteria are provided to indicate when the effects of the OBE are required to be considered explicitly in the seismic design of the subsystems.

   Meeting these requirements provides assurance that appropriate methods will be used to determine the structural response of subsystems, under the SSE and OBE (if applicable), which will ensure that they will remain functional within applicable acceptance limits.

III. REVIEW PROCEDURES

These review procedures are based on the identified DSRS acceptance criteria. For deviations from these acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

1. In accordance with 10 CFR 52.47(a)(8),(21), and (22), and 10 CFR 52.79(a)(17) and (20), for new reactor license applications submitted under Part 52, the applicant is required to (1) address the proposed technical resolution of unresolved safety issues and medium- and high-priority generic safety issues which are identified in the version of NUREG-0933 current on the date up to 6 months before the docket date of the application and which are technically relevant to the design; (2) demonstrate how the operating experience insights have been incorporated into the plant design; and, (3) provide information necessary to demonstrate compliance with any technically relevant portions of the Three Mile Island requirements set forth in 10 CFR 50.34(f), except paragraphs (f)(1)(xii), (f)(2)(ix), and (f)(3)(v). These cross-cutting review areas should be addressed by the reviewer for each technical subsection and relevant conclusions documented in the corresponding safety evaluation report (SER) section.

2. Seismic Analysis Methods. The seismic analysis methods are reviewed to determine that these are in accordance with the acceptance criteria of DSRS Section 3.7.2, subsection II.1.

3. Determination of Number of Earthquake Cycles. Criteria or procedures used to establish the number of earthquake cycles are reviewed to determine that they are in accordance with the acceptance criteria as given in subsection II.2 of this DSRS section. Justification for deviating from the acceptance criteria is requested from the applicant, as necessary.

4. Procedures Used for Analytical Modeling. The criteria and procedures used for modeling for the seismic subsystem analysis are reviewed to determine that these are in accordance with the acceptance criteria of DSRS Section 3.7.2, subsection II.3.

5. Basis for Selection of Frequencies. As applicable, criteria or procedures used to separate fundamental frequencies of components and equipment from the forcing frequencies of the support structure are reviewed to determine compliance with the acceptance criteria of subsection II.4 of this DSRS section.

6. Analysis Procedure for Damping. The analysis procedure to account for damping in different elements of the model of a coupled system is reviewed to determine that it is in accordance with the acceptance criteria of DSRS Section 3.7.2, subsection II.13.

7. Three Components of Earthquake Motion. The procedures by which the three components of earthquake motion are considered in determining the seismic response of subsystems are reviewed to determine compliance with the acceptance criteria of DSRS Section 3.7.2, subsection II.6.

8. Combination of Modal Responses. The procedures for combining modal responses are reviewed to determine compliance with the acceptance criteria of DSRS Section 3.7.2, subsection II.7 when a response spectrum modal analysis method is used.

9. Interaction of Other Systems with Seismic Category I Systems. The criteria used to design the interfaces between seismic Category I and non-seismic Category I systems are reviewed to determine compliance with the acceptance criteria of subsection II.8 of this DSRS section.

10. Multiply-Supported Equipment and Components with Distinct Inputs. The criteria for the seismic analysis of multiply-supported equipment and components with distinct inputs are reviewed to determine that the criteria are in accordance with the acceptance criteria of subsection II.9 of this DSRS section.

11. Use of Equivalent Vertical Static Factors. The procedures for the use of equivalent vertical static factors are reviewed to determine compliance with the acceptance criteria of DSRS Section 3.7.2, subsection II.10.

12. Torsional Effects of Eccentric Masses. The procedures for seismic analysis of Category I subsystems are reviewed to determine compliance with the acceptance criteria of subsection II.11 of this DSRS section.

13. Seismic Category I Buried Piping, Conduits, and Tunnels. The analysis procedures for seismic Category I buried piping, conduits, tunnels, and any other subsystems are reviewed to determine that they are in accordance with the acceptance criteria of subsection II.12 of this DSRS section.

14. Methods for Seismic Analysis of Seismic Category I Concrete Dams. Methods for the seismic analysis of seismic Category I concrete dams are reviewed to determine compliance with the acceptance criteria of subsection II.13 of this DSRS section.

15. Method for Seismic Analysis of Above-Ground Tanks. Methods for seismic analysis of seismic Category I above-ground tanks are reviewed to determine compliance with the acceptance criteria of subsection II.14 of this DSRS section.

16. DC and COL Applications. For review of a DC application, the reviewer should follow the above procedures to verify that the design, including requirements and restrictions (e.g., interface requirements and site parameters), set forth in the final safety analysis report (FSAR) meets the acceptance criteria. DCs have referred to the FSAR as the DCD. The reviewer should also consider the appropriateness of identified COL action items. The reviewer may identify additional COL action items; however, to ensure these COL action items are addressed during a COL application, they should be added to the DC FSAR.

    For review of a COL application, the scope of the review is dependent on whether the COL applicant references a DC, an early site permit (ESP) or other NRC approvals (e.g., manufacturing license, site suitability report or topical report).

    For review of both DC and COL applications, SRP Section 14.3 should be followed for the review of ITAAC. The review of ITAAC cannot be completed until after the completion of this section.

IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the review and calculations (if applicable) support conclusions of the following type to be included in the staff's safety evaluation report. The reviewer also states the bases for those conclusions.

Evaluation findings for DSRS Section 3.7.3 have been combined with those of DSRS Section 3.7.2 and are given under DSRS Section 3.7.2, subsection IV.

For DC and COL reviews, the findings will also summarize the staff's evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action items relevant to this DSRS section.

In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable.

V. IMPLEMENTATION

The staff will use this DSRS section in performing safety evaluations of mPower™-specific DC, COL, or ESP applications submitted by applicants pursuant to 10 CFR Part 52. The staff will use the method described herein to evaluate conformance with Commission regulations.

Because of the numerous design differences between the mPower™ and large light-water nuclear reactor power plants, and in accordance with the direction given by the Commission in SRM- COMGBJ-10-0004/COMGEA-10-0001, "Use of Risk Insights to Enhance the Safety Focus of Small Modular Reactor Reviews," dated August 31, 2010 (ADAMS Accession Number ML102510405), to develop risk-informed licensing review plans for each of the small modular reactor (SMR) reviews including the associated pre-application activities, the staff has developed the content of this DSRS section as an alternative method for mPower™-specific DC, COL, or ESP applications submitted pursuant to 10 CFR Part 52 to comply with 10 CFR 52.47(a)(9), "Contents of applications; technical information."

This regulation states, in part, that the application must contain "an evaluation of the standard plant design against the SRP revision in effect 6 months before the docket date of the application." The content of this DSRS section has been accepted as an alternative method for complying with 10 CFR 52.47(a)(9) as long as the mPower™ DCD FSAR does not deviate significantly from the design assumptions made by the NRC staff while preparing this DSRS section. The application must identify and describe all differences between the standard plant design and this DSRS section, and discuss how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria. If the design assumptions in the DC application deviate significantly from the DSRS, the staff will use the SRP as specified in 10 CFR 52.47 (a)(9). Alternatively, the staff may supplement the DSRS section by adding appropriate criteria in order to address new design assumptions. The same approach may be used to meet the requirements of 10 CFR 52.17 (a)(1)(xii) and 10 CFR 52.79 (a)(41), for ESP and COL applications, respectively.

VI. REFERENCES

1. 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities."

2. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomenon."

3. 10 CFR Part 50, Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants."

4. 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."

5. ASCE 4-98, "Seismic Analysis of Safety-Related Nuclear Structures and Commentary," American Society of Civil Engineers, [Section 3.5.2 for buried pipes and conduits, and Section 3.5.4 for above-ground vertical tanks].

6. ASCE Report, "Seismic Response of Buried Pipes and Structural Components," American Society of Civil Engineers," 1983.

7. Haroun, M. A., and Housner, G. W., "Seismic Design of Liquid Storage Tanks," Journal of the Technical Councils, ASCE, Vol. 107, No. TC1, pp. 191-207, 1981.

8. IEEE Standard 344-1987, "IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations, Appendix D, “Test Duration and Number of Cycles," Institute of Electrical and Electronics Engineers, June 1987.

~~9.~~ NUREG-1061, "Report of the U.S. Nuclear Regulatory Commission Piping Review Committee; Volume 4: Evaluation of Other Loads and Load Combinations," December 1984.

10. NUREG/CR-1161, "Recommended Revisions to Nuclear Regulatory Commission Seismic Design Criteria," May 1980.

11. Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants."

12. Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)."

13. SRM SECY 93-087, Staff Requirement Memorandum: "SECY-93-087 - Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs" (ADAMS Accession Number ML003708056).

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