C.I.3 Design of Structures, Systems, Components, and Equipment

Chapter 3 of the final safety analysis report (FSAR) should identify, describe, and discuss the principal architectural and engineering design of those structures, systems, and components (SSCs), and equipment that are important to safety.

C.I.3.1 *Conformance with U.S. Nuclear Regulatory Commission General Design Criteria*

The applicant should discuss the extent to which plant SSCs important to safety meet the U.S. Nuclear Regulatory Commission's (NRC's) criteria in Appendix A, "General Design Criteria for Nuclear Power Plants," to Title 10, Part 50, "Domestic Licensing of Production and Utilization Facilities," of the *Code of Federal Regulations* (10 CFR Part 50). For each applicable criterion, the applicant should provide a summary showing how the principal design features meet the general design criteria (GDC) and should identify and justify any exceptions to the GDC. The discussion of each criterion should identify the sections of the FSAR that present more detailed information to demonstrate compliance with or exceptions to the GDC.

C.I.3.2 *Classification of Structures, Systems, and Components*

C.I.3.2.1 Seismic Classification

The applicant should identify those SSCs important to safety that are designed to withstand the effects of earthquakes without loss of capability to perform their safety functions.

Plant features, including foundations and supports, that are designed to remain functional in the event of a safe-shutdown earthquake (SSE) (see FSAR Section 2.5) or surface deformation should be designated as seismic Category I. Specifically, the plant features of interest are those necessary to ensure the following characteristics:

(1) integrity of the reactor coolant pressure boundary (RCPB)

(2) capability to shut down the reactor and maintain it in a safe shutdown condition

(3) capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposures comparable to the guideline exposures of 10 CFR 50.34(a)(1) and 10 CFR 52.79.

Regulatory Guide 1.29, "Seismic Design Classification," contains guidance for identifying seismic Category I SSCs. The applicant should provide a list of all seismic Category I items and indicate whether it has followed the recommendations of Regulatory Guide 1.29. If only portions of structures and systems are seismic Category I, the applicant should list them and, where necessary for clarity, show the boundaries of the seismic Category I portions on piping and instrumentation diagrams. The applicant should also identify portions of SSCs not required to continue functioning, but the failure of which could reduce the functioning of any seismic Category I plant feature to an unacceptable safety level or could result in incapacitating injury to control room occupants. The SSCs should be designed and constructed so that the SSE would not cause such failure. The applicant should identify any differences from the recommendations of Regulatory Guide 1.29 and discuss the proposed classification. Regulatory Guide 1.143, "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants," provides recommendations for determining the seismic design of SSCs of radioactive waste management facilities. The applicant should identify the radioactive waste management SSCs that require seismic design considerations and discuss differences from the recommendations of Regulatory Guide 1.143.

Regulatory Guide 1.151, “Instrument Sensing Lines,” offers recommendations for determining the seismic design of instrument sensing lines. The applicant should identify the instrument sensing lines that require seismic design considerations and discuss differences from the recommendations of Regulatory Guide 1.151.

The applicant should list or otherwise clearly identify all SSCs or portions thereof that are designed for an operating-basis earthquake (OBE).

C.I.3.2.2 <u>System Quality Group Classification</u>

The applicant should identify those fluid systems or portions thereof that are important to safety, as well as the applicable industry codes and standards for each pressure-retaining component.

Section 50.55a, “Codes and Standards,” of 10 CFR Part 50 specifies quality requirements for the RCPB, and Regulatory Guide 1.26 describes a quality group classification system and relates it to industry codes for water- and steam-containing fluid systems. Regulatory Guide 1.143 provides recommendations regarding system quality group classification and/or standards for radioactive waste management systems, and Regulatory Guide 1.151 provides this same information for instrument sensing lines. The applicant should indicate the extent to which it has followed the recommendations of Regulatory Guide 1.26, Regulatory Guide 1.143, and Regulatory Guide 1.151. The applicant should identify any differences between the recommendations and its application and justify each proposed quality group classification in terms of the reliance placed on those systems that perform any of the following functions:

(1) prevent or mitigate the consequences of accidents and malfunctions originating within the RCPB
(2) permit reactor shutdown and maintenance in the safe shutdown condition
(3) contain radioactive material

For such systems, the applicant should specify the proposed design features and measures that it would apply to attain a quality level equivalent to the level of the Regulatory Guide 1.26, Regulatory Guide 1.143 and Regulatory Guide 1.151 classifications (as applicable), including the quality assurance programs that would be implemented. The applicant should discuss the group classification boundaries of each safety-related system. The classifications should be marked/noted on drawings at valves or other appropriate locations in each fluid system where the respective classification changes in terms of the NRC group classification letters (for example, from A to B, B to C, C to D, as well as other combinations) or, alternatively, in terms of corresponding classification notations that can be referenced with those classification groups in Regulatory Guide 1.26, Regulatory Guide 1.143, and Regulatory Guide 1.151 as applicable.

C.I.3.3 *Wind and Tornado Loadings*

C.I.3.3.1 <u>Wind Loadings</u>

To define the design-basis wind loadings of seismic Category I structures, the applicant should provide the following:

(1) the design wind velocity and its recurrence interval, the importance factor, and the exposure category

(2) the methods used to transform the wind velocity into an effective pressure applied to surfaces of structures and present the results in tabular form for plant SSCs, as well as current references for the basis, including the assumptions

Provide information showing that the failure of the facility structures or components not included in the scope of the referenced certified design and are not designed for wind loads will not affect the ability of other structures to perform their intended safety functions.

C.I.3.3.2 <u>Tornado Loadings</u>

The applicant should define the design-basis tornado loadings on structures that must be designed to withstand tornadoes. It should include the following specific information in the description:

(1) design parameters applicable to the design-basis tornado, including the maximum tornado velocity, the pressure differential and its associated time interval, and the spectrum and pertinent characteristics of tornado-generated missiles

(2) the methods used to transform the tornado loadings into effective loads on structures

- (a) methods used to transform the tornado wind into an effective pressure on exposed surfaces of structures, including consideration of geometrical configuration and physical characteristics of the structures and the distribution of wind pressure on the structures
- (b) if venting of a structure is used, the methods employed to transform the tornado-generated differential pressure into an effective reduced pressure
- (c) the methods used to transform the tornado-generated missile loadings, which are considered impactive dynamic loads, into effective loads
- (d) the various combinations of the above individual loadings that will produce the most adverse total tornado effect on structures

The applicant should provide information showing that the failure of any structure or component that is not designed for tornado loads will not affect the ability of other structures to perform their intended safety functions.

C.I.3.4 *Water Level (Flood) Design*

C.I.3.4.1 <u>Internal Flood Protection</u>

Describe the internal flood protection measures for all SSCs whose failure could prevent safe shutdown of the plant or result in uncontrolled release of significant radioactivity. The information provided in this section of the FSAR should be consistent with the information provided in FSAR Sections 2.4 and 2.5 for safe shutdown ground motion, as well as FSAR Section 3.8.4 for seismic design, which should be referenced as appropriate:

1. Identify and evaluate the SSCs that are safety related and must be protected against internal floods and flood conditions.

2. Identify the location of safety-related SSCs in relation to the internal flood levels in various areas that house safety-related SSCs.

3. Identify and evaluate SSCs, if any, that may be potential sources of internal flooding (e.g. pipe breaks and cracks, tank and vessel failures, backflow through drains.)

4. If flood protection is required, discuss the adequacy of techniques such as enclosures, pumping systems, drains, internal curbs, and watertight doors used to prevent flooding of

safety-related systems or components. Identify the above mentioned techniques by using plant arrangements, layout drawings or any other acceptable method.

5. Discuss the measures taken to assess the potential flooding of SSCs important to safety due to the operation of the fire protection systems and the postulated failure of piping in accordance with Section 3.6.2. Postulated failures of non-seismic and non-tornado protected piping, tanks, and vessels should be assessed. For the purposes of the flood analysis, the assumption can be made, for each analyzed area, the rupture of the single, worst-case pipe (or non-seismic tank/vessel). For moderate energy piping that is not seismically supported should be considered for full circumferential ruptures, not just cracks.

   Ways to mitigate the consequences of potential internal flooding to safety-related systems, such as drains and sump pumps should be considered in this assessment. Take into consideration if the postulated break occurs in a non-seismically supported system, then only seismically-qualified systems should be assumed available to mitigate the effects of the analyzed break (a seismic event may have caused the initial break.)

6. Discuss the risk assessment for external and internal flooding to identify potentially significant vulnerabilities to flooding. This will include an analysis of flooding during shutdown conditions. Determine if flooding consequences that result from failures of liquid carrying systems in the proximity of essential equipment will not preclude the required functions of safety systems with a failure mode and effects analysis.

7. Identify and evaluate those safety-related systems or components, if any, that are capable of normal functions while completely or partially flooded.

8. Determine, if any, safety-related equipment or components (on plant arrangement and layout drawings) are located within individual compartments or cubicles which may function as positive barriers against potential means of flooding, and if barriers or other means of physical separation are used between redundant safety-related trains. Evaluate the adequacy of such barriers. Identify potential flow paths from connected nonsafety-related areas to rooms that contain safety-related SSCs.

9. Identify and describe the design features that will be used to mitigate the effects of internal flooding (adequate drainage, sump pumps, etc.) These features should be safety-related to ensure adequate time to perform a safe shutdown. Only seismically-qualified systems may be assumed to be available to mitigate the effects of the flooding from a non-seismic systems.

Describe the flood protection of any safety-related structure dependent on a permanent dewatering system from the effects of ground water:

- Provide a summary description of the dewatering system, including all major subsystems. The dewatering systems should be designed as a safety-related system and meet the single failure criterion requirements.

- Describe the design bases for the functional performance requirements for each subsystem, along with the bases for selecting the system operating parameters.

- Demonstrate the system satisfies the design bases, the system's capability to withstand design-basis events, and its capability to perform its safety function assuming a single active failure with the loss of offsite power. Evaluate the protection against single failure in terms of piping arrangement and layout, selection of valve types and locations, redundancy of various system components, redundancy of power supplies, redundant sources of actuation signals, and redundancy of instrumentation. Demonstrate that the dewatering system is protected from the effects of pipe breaks and missiles.

- Describe the testing and inspection to be performed to verify that the system has the required capability and reliability, as well as the instrumentation and controls necessary for proper operation of the system.

C.I.3.4.2 <u>Analysis Procedures</u>

The applicant should describe the methods and procedures by which the static and dynamic effects of the design-basis flood or groundwater conditions identified in Section 2.4 of the FSAR are applied to seismic Category I structures that are designated as providing protection against external flooding. For each seismic Category I structure that may be affected, the applicant should summarize the design-basis static and dynamic loadings, including consideration of hydrostatic loadings, equivalent hydrostatic dynamically induced loadings, coincident wind loadings, and the static and dynamic effects on foundation properties (see Section 2.5 of the FSAR).

The applicant should describe any physical models used to predict prototype performance of hydraulic structures and systems. Regulatory Guide 1.125, "Physical Models for Design and Operation of Hydraulic Structures and Systems for Nuclear Power Plants," provides guidance.

C.I.3.5 *Missile Protection*

C.I.3.5.1 <u>Missile Selection and Description</u>

C.I.3.5.1.1 ***Internally Generated Missiles (Outside Containment)***

The applicant should identify all structures, systems (or portions of systems), and components that are to be protected against damage from internally generated missiles. These are the SSCs necessary to perform functions required to attain and maintain a safe shutdown condition or to mitigate the consequences of an accident. Regulatory Guide 1.117, "Tornado Design Classification," provides guidance on the SSCs that should be protected. The applicant should consider missiles associated with overspeed failures of rotating components (e.g., motor-driven pumps and fans), failures of high-pressure system components, and gravitational missiles (e.g., falling objects resulting from a nonseismically designed SSC during a seismic event). The design bases should consider the design features provided for either continued safe operation or shutdown during all operating conditions, operational transients, and postulated accident conditions.

The applicant should provide the following information for those SSCs outside containment that require protection from internally generated missiles:

(1) locations of the SSCs

(2) applicable seismic category and quality group classifications (information may be referenced from FSAR Section 3.2)

(3) sections of the FSAR where the items are described, including applicable drawings or piping and instrumentation diagrams

(4) missiles to be protected against, their sources, and the bases for their selection for analysis

(5) missile protection provided

Applicants should evaluate the ability of the SSCs to withstand the effects of selected internally generated missiles. Examples of missiles to be considered are noted above. For protection against low trajectory turbine missiles, the protection provided should meet the guidance of Regulatory Position 3 of Regulatory Guide 1.115, "Protection Against Low-Trajectory Turbine Missiles."

C.I.3.5.1.2 ***Internally Generated Missiles (Inside Containment)***

The applicant should identify all plant SSCs inside containment that should be protected from internally generated missiles. These are the SSCs whose failure could lead to offsite radiological consequences or those required for safe plant shutdown. The applicant should identify credible missiles associated with overspeed failures of rotating components (e.g., pumps, fans, compressors), primary and secondary failures of high-pressure system components (e.g., reactor vessel, steam generator, pressurizer, core makeup tanks, accumulators, reactor coolant pump casings, passive residual heat exchanger, piping), gross failure of a control rod drive mechanism, hydrogen explosion inside containment, and gravitational effects (e.g., falling objects resulting from the movement of a heavy load or a nonseismically designed SSC during a seismic event, secondary missiles caused by a falling object striking a high-energy system).

For those SSCs important to safety inside containment and that need to be protected against internally generated missiles, the applicant should provide the following information:

(1) location of the SSCs

(2) missiles to be protected against, their sources, and the bases for their selection for analysis

(3) missile protection provided (identify SSCs protected by physical barriers and, for those protected by redundancy, demonstration of the separation and independence)

(4) an evaluation demonstrating the ability of the SSCs to withstand the effects of selected internally generated missiles

C.I.3.5.1.3 ***Turbine Missiles***

The applicant should provide the information listed below to demonstrate that SSCs important to safety have adequate protection against the effects of potential turbine missiles. (Regulatory Guide 1.117 describes examples of SSCs important to safety that should be protected.)

(1) Indication of whether the orientation of the turbine is favorable or unfavorable relative to the placement of the containment and other SSCs important to safety. Favorably oriented turbine generators are located such that the containment and all, or almost all, SSCs important to safety located outside containment are excluded from the low-trajectory hazard zone described in Regulatory Guide 1.115. This section should include the following information to justify the turbine's orientation (information provided in other sections may be referenced as appropriate):

    (a) dimensioned plant layout drawings (plan and elevation views) with the turbine and containment buildings clearly identified

    (b) barriers, including structural wall material strength properties and thickness

(c) SSCs important to safety in terms of location, redundancy, and independence

(d) all turbine generator units (present and future) in the vicinity of the plant being reviewed

(e) a quantitative description of the turbine generator in terms of rotor shaft, wheels/buckets/blades, steam valve characteristics, rotational speed, and turbine internals pertinent to turbine missile analyses

(f) postulated missiles in terms of missile size, mass, shape, and exit speed for design overspeed and destructive overspeed in postulated turbine failures (description of the analysis used in estimating the missile exit speeds and identification of the direction of rotation for each turbine generator under consideration)

(2) The methods, analyses, and results for the turbine missile generation probability calculations.

(3) Description of the inservice inspection and testing program that will be used to maintain an acceptably low probability of missile generation.

(4) Demonstration of the structural capability of any barriers (or structures used as barriers) that protect SSCs to withstand turbine missiles in the event of a turbine failure.

C.I.3.5.1.4 ***Missiles Generated by Tornadoes and Extreme Winds***

The applicant should identify all missiles generated as a result of high-speed winds such as tornadoes, hurricanes, and any other extreme winds. For selected missiles, the applicant should specify the origin (including height above plant grade), dimensions, mass, energy, velocity, trajectory, and any other parameters required to determine missile penetration. Regulatory Guide 1.76, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants," contains guidance for selecting the design-basis, tornado-generated missiles.

C.I.3.5.1.5 ***Site Proximity Missiles (Except Aircraft)***

The applicant should identify all missile sources resulting from accidental explosions in the vicinity of the site, based on the nature and extent of nearby industrial, transportation, and military facilities (other than aircraft) identified in Sections 2.2.1–2.2.3 of the FSAR. The applicant should consider the following missile sources with respect to the site:

(1) train explosions (including rocket effects)
(2) truck explosions
(3) ship or barge explosions
(4) industrial facilities (where different types of materials are processed, stored, used, or transported)
(5) pipeline explosions
(6) military facilities

The applicant should identify the SSCs listed in Section 3.5.2 of the FSAR that have the potential for unacceptable missile damage and estimate the total probability of the missiles striking a vulnerable critical area of the plant. If the total probability is greater than an order of magnitude of 10^{-7} per year, a specific missile description, including size, shape, weight, energy, material properties, and trajectory, should accompany the description of the missile effects on the SSCs.

C.I.3.5.1.6 *Aircraft Hazards*

The applicant should provide an aircraft hazard analysis for each of the following:

(1) Federal airways, holding patterns, or approach patterns within 3.22 kilometers (2 miles) of the nuclear facility

(2) all airports located within 8.05 kilometers (5 statute miles) of the site

(3) airports with projected operations greater than $193d^2$ ($500d^2$) movements per year located within 16.10 kilometers (10 statute miles) of the site and greater than $386d^2$ ($1000d^2$) outside 16.10 kilometers (10 statute miles), where d is the distance in kilometers (statute miles) from the site

(4) military installations or any airspace usage that might present a hazard to the site (for some uses, such as practice bombing ranges, it may be necessary to evaluate uses as far as 32.19 kilometers (20 statute miles) from the site)

Hazards to the plant may be divided into accidents resulting in structural damage and accidents involving fire. These analyses should be based on the projected traffic for the facilities, the aircraft accident statistics provided in Section 2.2, and the critical areas described in Section 3.5.2 of the FSAR.

The aircraft hazard analysis should provide an estimate of the total aircraft hazard probability per year. The plant design should consider aircraft accidents that could lead to radiological consequences in excess of the exposure guidelines of 10 CFR 50.34(a)(1) and 10 CFR 52.79 with a probability of occurrence greater than an order of magnitude of 10^{-7} per year. The applicant should provide and justify the aircraft selected as the design-basis impact event, including its dimensions, mass (including variations along the length of the aircraft), energy, velocity, trajectory, and energy density. Section 3.5.3 of the FSAR should provide the resultant loading curves on structures.

All parameters used in these analyses should have an explicit justification. Wherever a given parameter has a range of values, this should be plainly indicated and the most conservative value used. The applicant should state a clear justification for all assumptions.

C.I.3.5.2 <u>Structures, Systems, and Components To Be Protected from Externally Generated Missiles</u>

The applicant should identify the SSCs that should be protected from externally generated missiles. These are the SSCs necessary for safe shutdown of the reactor facility and those whose failure could result in a significant release of radioactivity. Structures (or areas of structures), systems (or portions of systems), and components should be protected from externally generated missiles if such a missile could prevent the intended safety function. If a missile impact on a non-safety-related system, its failure could degrade the intended function of a safety-related system, the system is classified under the regulatory treatment of non-safety-related systems (RTNSS). The SSC under this category needs adequate separation from safety-related SSCs that any failure of a non-safety-related SSC should not prevent a safety-related SSC from performing its intended functions. Guidance on the SSCs that should be protected against externally generated missiles appears in Regulatory Position 2 of Regulatory Guide 1.13, "Spent Fuel Storage Facility Design Basis"; Regulatory Positions 2 and 3 of Regulatory Guide 1.27, "Ultimate Heat Sink for Nuclear Power Plants"; Regulatory Position C.1 of Regulatory Guide 1.115; and Regulatory Positions 1–3 and the appendix to Regulatory Guide 1.117.

C.I.3.5.3 Barrier Design Procedures

The applicant should provide the following information concerning the design of each structure or barrier to resist the missile hazards previously described:

(1) methods used to predict local damage in the impact area, including estimation of the depth of penetration

(2) methods used to estimate barrier thickness required to prevent perforation

(3) methods used to predict concrete barrier potential for generating secondary missiles by spalling and scabbing effects

(4) methods used to predict the overall response of the barrier and portions thereof to missile impact, including assumptions on acceptable ductility ratios and estimates of forces, moments, and shears induced in the barrier by the impact force of the missile

C.I.3.6 *Protection against Dynamic Effects Associated with Postulated Rupture of Piping*

The applicant should describe design bases and design measures used to ensure that the containment vessel and all essential equipment inside or outside the containment, including components of the RCPB, have been adequately protected against the effects of blowdown jet and reactive forces and pipe whip resulting from postulated rupture of piping located either inside or outside of containment.

C.I.3.6.1 <u>Plant Design for Protection against Postulated Piping Failures in Fluid Systems Outside of Containment</u>

The applicant should describe the plant design for protection against high- and moderate-energy fluid system piping failures outside containment to ensure that such failures would not cause the loss of needed functions of systems important to safety and ensure that the plant could be safely shut down in the event of such failures. Recommended actions include the following:

(1) Identify systems or components important to plant safety or shutdown that are located proximate to high- or moderate-energy piping systems and that are susceptible to the consequences of failures of these piping systems

(a) Relate the identification to predetermined piping failure locations in accordance with Section C.I.3.6.2 of this guide. Provide drawings indicating typical piping runs with failure points.

(b) Identify those conditions under which the component may still operate.

(c) Indicate the design approach taken to protect the systems and components identified above.

(2) Provide a list of high- and moderate-energy lines

(a) Submit a description of the layout of all piping systems where physical arrangement of the piping systems provides the required protection.

(b) Provide a description of the design basis of structures and compartments used to protect nearby essential systems or components.

(c) Describe the arrangements to ensure the operability of safety features where neither separation nor protective enclosures are practical.

(3) Provide a failure mode and effects analysis to verify that the consequences of failures of high- and moderate-energy lines do not affect the ability to safely shut down the plant

(a) Identify the locations and types of failures considered (e.g., circumferential or longitudinal pipe breaks, through-wall cracks, leakage cracks) and the dynamic effects associated with the failures (e.g., pipe whip, jet impingement). Also consider the potential effects of secondary missiles.

(b) Explain the assumptions made in the analyses with respect to the following:

- availability of offsite power
- failure of single active components in systems used to mitigate the consequences of the piping failure
- special provisions applicable to certain dual-purpose systems
- use of available systems to mitigate the consequences of the piping failure

(c) Describe the effects of piping failures in systems not designed to seismic Category I standards on essential systems and components, assuming concurrent failure of a single active component and a loss of offsite power.

(d) Describe the environmental effects of pipe rupture (e.g., temperature, humidity, pressure, spray-wetting, flooding), including potential transport of the steam environment to other rooms or compartments, and the subsequent effects on the functional performance of essential electrical equipment and instrumentation.

(e) Describe the effects of postulated failures on habitability of the control room and access to areas important to safe control of postaccident operations.

C.I.3.6.2 <u>Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping</u>

The applicant should describe the criteria for determining the location and configuration of postulated breaks and cracks in high- and moderate-energy piping inside and outside of containment; the methods used to define the jet thrust reaction at the break or crack location and the jet impingement loading on adjacent safety-related SSCs; and the design criteria for pipe whip restraints, jet impingement barriers and shields, and guard pipes.

C.I.3.6.2.1 *Criteria Used to Define Break and Crack Location and Configuration*

The applicant should provide the criteria used to determine the location and configuration of postulated breaks and cracks in those high- and moderate-energy piping systems for which separation or enclosure cannot be achieved. In the case of containment penetration piping, in addition to the material requested above, the applicant should provide details of the containment penetration identifying all process pipe welds, access for inservice inspection of welds, points of fixity, and points of geometric discontinuity. The applicant should discuss the implementation of criteria for defining pipe break and crack locations and configurations and provide the resulting number and location of design-basis breaks and cracks. The discussion should also include the postulated rupture orientation (such as circumferential and/or longitudinal break) for each postulated design-basis break location.

C.I.3.6.2.2 *Guard Pipe Assembly Design Criteria*

The applicant should describe the details of protective assemblies or guard pipes to be used for piping penetrations of containment areas. (A guard pipe is a device to limit pressurization of the space between dual barriers of certain containments to acceptable levels.) The applicant should discuss whether such protective assemblies provide an extension of containment, prevent overpressurization, or both. The applicant should identify where moment-limiting restraints are used at the extremities or within the protective assembly and provide the design criteria for the process pipe within the protective assembly, fluid heads and bellows expansion joints, and the guard pipe used with the assembly. In addition, the applicant should describe the method of providing access and the location of access openings to permit periodic examinations of all process pipe welds within the protective assembly, as required by the plant's inservice inspection program (refer to Section 5.2.4 of the FSAR for American Society of Mechanical Engineers (ASME) Class 1 systems, and Section 6.6 for ASME Class 2 and 3 systems). The applicant should discuss the implementation of the design criteria relating to protective assemblies or guard pipes, including their final design and arrangement of the access openings used to examine all process pipe welds within such protective assemblies to meet the requirements of the plant's inservice inspection program.

C.I.3.6.2.3 ***Analytical Methods To Define Forcing Functions and Response Models***

The applicant should describe the analytical methods for defining the forcing functions to be used for the pipe whip dynamic analyses. This description should include direction, thrust coefficients, rise time, magnitude, duration, and initial conditions that adequately represent the jet stream dynamics and the system pressure differences. Pipe restraint rebound effects should be included if appropriate. The applicant should provide diagrams of typical mathematical models used for the dynamic response analysis and present and justify all dynamic amplification factors to be used. The discussion should cover the implementation of the methods used for the pipe whip dynamic analyses to demonstrate the acceptability of the analysis results, including the jet thrust and impingement functions and the pipe whip dynamic effects.

C.I.3.6.2.4 ***Dynamic Analysis Methods To Verify Integrity and Operability***

The applicant should describe the analytical methods, including the details of jet expansion modeling, that it will use to evaluate the jet impingement effects and loading effects applicable to nearby SSCs resulting from postulated pipe breaks and cracks. In addition, the applicant should provide the analytical methods used to verify the integrity and operability of these impacted SSCs under postulated pipe rupture loads. In the case of piping systems that include pipe whip restraints, the applicant should provide loading combinations and design criteria for the restraints along with a description of the typical restraint configuration to be used. The applicant should discuss the implementation of the dynamic analysis methods used to verify the integrity and operability of the impacted SSCs and should demonstrate the design adequacy of these SSCs to ensure that pipe whip or jet impingement loading will not impair their design-intended functions to an unacceptable level of integrity or operability.

C.I.3.6.2.5 ***Implementation of Criteria Dealing with Special Features***

The applicant should discuss the implementation of criteria dealing with special features, such as an augmented inservice inspection program or use of special protective devices (such as pipe whip restraints). The discussion should include diagrams showing the final configurations, locations, and orientations of the special features in relation to break locations in each piping system.

C.I.3.6.3 **Leak-before-Break Evaluation Procedures**

The applicant should describe the analyses used to eliminate from the design basis the dynamic effects of certain pipe ruptures and demonstrate that the probability of pipe rupture is extremely low under conditions consistent with the design basis for the piping. The applicant should give adequate consideration to direct and indirect pipe failure mechanisms and other degradation sources that could challenge the integrity of piping. Information to be provided includes the following:

(1) List of the piping systems included in the leak-before-break (LBB) evaluation.

(a) Identify the types of as-built materials and material specifications used for base metal, weldments, nozzles, and safe ends.

(b) the material properties, including the following:

- toughness (J-R curves) and tensile (stress-strain curves) data at temperatures near the upper range of normal plant operation
- long-term effects attributable to thermal aging
- yield strength and ultimate strength

(c) the welding process/method (e.g.,submerged arc welding) used in the weld(s)

If the as-built materials and material specifications are not available at the time of the COL application, representative and bounding materials and associated specifications may be used in the LBB analysis to be submitted with the COL application. The applicant should in the COL application agree on an appropriate method (e.g., ITAAC, license condition, FSAR) to ensure that the as-built plant is consistent with the design reviewed during the licensing process.

(2) Discussion of the design-basis loads for each piping system.

(a) Provide as-built drawing(s) of pipe geometry (e.g., piping isometric drawings). Identify locations of supports and their characteristics (such as gaps). Identify the analysis nodal points. If as-built drawings are not available at the time of COL application, design piping isometric drawings may be submitted. The applicant should in the COL application agree on an appropriate method (e.g., ITAAC, license condition, FSAR) to ensure that the as-built plant is consistent with the design reviewed during the licensing process.

(b) locations and weights of components such as valves

(c) snubber reliability

(d) the sources (e.g., thermal, deadweight, seismic, and seismic anchor movement), types (e.g., forces, bending and torsional moments), and magnitudes of applied loads and the method of combination

If as-built drawings, weight of components, and analysis loads are not available at the time of the COL application, design piping isometric drawings and analysis may be submitted. The applicant should in the COL application agree on an appropriate method (e.g., ITAAC, license condition, FSAR) to ensure that the as-built plant is consistent with the design reviewed during the licensing process.

(3) Deterministic fracture mechanics analysis. This analysis should identify the locations that have the least favorable combination of stress and material properties for base metal, weldment, and safe ends and should postulate a through-wall leakage flaw at these locations. The analysis should demonstrate that the leakage flaw has sufficient safety margin with respect to the critical crack size under various loading combinations, that leakage flaw growth would be stable, and that the final flaw size would be limited such that a double-ended pipe break would not occur.

(4) Leak rate evaluation to demonstrate that there is sufficient margin between the leak rate from the leakage flaw and the detection capability of the leak rate detection systems. This evaluation should demonstrate that the leak rate detection systems are sufficiently reliable, redundant, and sensitive to provide adequate margin on the detection of unidentified leakage. Regulatory Guide

1.45, "Reactor Coolant Pressure Boundary Leakage Detection Systems," provides guidance on acceptable methods for detecting and identifying the location of the leakage source.

(5) Evaluations demonstrating that degradation by erosion, erosion/corrosion, and erosion/cavitation attributable to unfavorable flow conditions and water chemistry are not potential sources of pipe rupture.

(6) Systems evaluation of potential water hammer, demonstrating that pipe rupture attributable to this mechanism is unlikely in the candidate piping system throughout the life of the plant. The applicant should identify historical water hammer frequencies, operating procedures and conditions, and design changes (e.g., J-tubes, vacuum breakers, jockey pumps) used in the evaluation.

(7) Evaluation of creep and creep-fatigue and demonstration that the piping material is not susceptible to brittle cleavage-type failure over the full range of system operating temperatures.

(8) Demonstration of the corrosion resistance of the piping under review. Identification of the measures taken to improve the corrosion resistance of the piping (such as modification to operating conditions (e.g., water chemistry, flow velocity, operating temperature, steam quality) and design changes (e.g., replacement piping material)).

(9) Demonstration that the piping systems under LBB evaluation do not have a history of fatigue cracking or failure.

   (a) Show that the potential for pipe rupture attributable to thermal and mechanical induced fatigue is unlikely.

   (b) Demonstrate that there is adequate mixing of high- and low-temperature fluids so that there is no potential for significant cyclic thermal stresses.

   (c) Show that there is no significant potential for vibration-induced fatigue cracking or failure.

(10) Demonstration that the following indirect failure mechanisms (as defined in the FSAR) are remote causes of pipe failure:

- seismic events
- system overpressurization attributable to accidents resulting from human error
- fires
- flooding causing electrical and mechanical control systems to malfunction
- missiles from equipment failure
- damage from moving equipment
- failures of SSCs in proximity to the piping

(11) Description of any inspection programs developed for piping systems that are qualified for LBB.

(12) Demonstration that the piping and weld materials are not susceptible to stress-corrosion cracking (such as primary water stress-corrosion cracking, intergranular stress-corrosion cracking, and transgranular stress-corrosion cracking).

C.I.3.7 *Seismic Design*

C.I.3.7.1 Seismic Design Parameters

The applicant should discuss the seismic design parameters (design ground motion, percentage of critical damping values, supporting media for seismic Category I structures) that are used as input parameters to the seismic analysis of seismic Category I SSCs for the OBE and SSE.

C.I.3.7.1.1 *Design Ground Motion*

The applicant should specify the earthquake ground motion (ground motion response spectra and/or ground motion time histories) exerted on the structure or the soil-structure interaction (SSI) system based on seismicity and geologic conditions at the site, expressed such that it can be applied to dynamic analysis of seismic Category I SSCs. The earthquake ground motion should consider the three components of design ground motions, two horizontal and one vertical, for the OBE and SSE. For the SSI system, this ground motion should be consistent with the free-field ground motion at the site. Additional guidance is provided in Regulatory Guide 1.208, "A Performance-Base Approach to Define the Site Specific Earthquake Ground Motion."

C.I.3.7.1.1.1 Design Ground Motion Response Spectra

The applicant should provide design ground motion response spectra for the OBE and SSE, which are consistent with those defined based on the guidelines in Section 2.5 of the FSAR. In general, these response spectra are developed for 5-percent damping. If the ground response spectra are different from the generic ground response spectra, such as the response criteria provided in Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants," the applicant should describe the procedures to calculate the response spectra for each damping ratio to be used in the design of seismic Category I SSCs and the procedures for the development of target power spectral density (PSD). The applicant should also provide bases to justify its choices to apply the response spectra either at the finished grade in the free field or at the various foundation locations of seismic Category I structures.

For combined operating license (COL) plants, the applicant should develop a site-specific ground spectrum from a probabilistic seismic hazard analysis (PSHA) in accordance with Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion," or the equivalent. However, NUREG/CR-6728, "Technical Basis for Regulatory Guidance on Design Ground Motions: Hazard- and Risk-Consistent Ground Motion Spectra Guidelines," issued in 2001, does not specify spectrum matching for damping other than 5 percent and target PSD enveloping. Another option, provided in Standard Review Plan (SRP) Section 3.7.1, is to develop the target PSD for ground response spectra other than the Regulatory Guide 1.60 ground response spectra, including ground response spectra developed from PSHA.

C.I.3.7.1.1.2 Design Ground Motion Time History

The applicant should describe how it selected or developed the earthquake ground motion time history (actual or synthetic). For the time history analyses, the applicant should provide the response spectra derived from actual or synthetic earthquake time-motion records. For each of the damping values to be used in the design of SSCs, this description should include a comparison of the response spectra obtained in the free field at the finished grade level and at the foundation level (obtained from an appropriate time history at the base of the SSI system) with the design response spectra. Alternatively, if the design response spectra for the OBE and SSE are applied at the foundation levels of seismic

Category I structures in the free field, the applicant should provide a comparison of the free-field response spectra at the foundation level (derived from an actual or synthetic time history) with the design response spectra for each of the damping values to be used in the design. If the seismic analysis is using the synthetic time history (three components), the applicant should demonstrate that (1) the cross-correlation coefficients between the three components of the design ground motion time histories are within the criteria of SRP Section 3.7.1, and (2) the PSD calculated from these three components envelop the target PSD developed based on the guidance in Section C.I.3.7.1.1.1 of this document. Also, the applicant should identify the period intervals at which the spectra values were calculated.

For COL plants, the discussion of PSHA in Section C.I.3.7.1.1.1 above applies.

C.I.3.7.1.2 ***Percentage of Critical Damping Values***

The applicant should specify the percentage of critical damping values used for seismic Category I SSCs and soil for both the OBE and SSE (e.g., damping ratios for the type of construction or fabrication). Also, the applicant should compare the damping ratios assigned to SSCs with the acceptable damping ratios provided in Regulatory Guide 1.61, "Damping Values for Seismic Design of Nuclear Power Plants," and include the bases for any proposed damping ratios that differ from those given in Regulatory Guide 1.61 for the proposed soil damping.

C.I.3.7.1.3 ***Supporting Media for Seismic Category I Structures***

For each seismic Category I structure, the applicant should describe the supporting media, including foundation embedment depth, depth of soil over bedrock, soil layering characteristics, dimensions of the structural foundation, total structural height, and soil properties of each soil layer, such as shear wave velocity, shear modulus, soil material damping, and density. The applicant should use this information to evaluate the suitability of either a finite element or lumped soil-spring approach for modeling soil foundation in the SSI analysis.

C.I.3.7.2 **<u>Seismic System Analysis</u>**

The applicant should discuss the seismic system analyses applicable to seismic Category I SSCs.

C.I.3.7.2.1 ***Seismic Analysis Methods***

For all seismic Category I SSCs, the applicant should identify and describe the applicable seismic analysis methods (e.g., response spectrum analysis, modal time history analysis, direct integration time history analysis, frequency domain time history analysis, equivalent static load analysis). The discussion should address how the dynamic system analysis method covers foundation torsion, rocking, and translation. The applicant should indicate which analysis method it will use for seismic Category I and non-seismic Category I (seismic Category II and nonseismic) SSCs. Seismic Category II SSCs are defined as SSCs that perform no safety-related function and the continued function of which is not required. However, the design of these SSCs should ensure that the SSE does not cause unacceptable failure of or interaction with seismic Category I items. The applicant should describe the types of soil-structure system models to be analyzed and which analysis methods it will use. The applicant should also indicate the manner in which the seismic dynamic analysis considers the maximum relative displacement among supports.

The applicant should indicate other significant effects accounted for in the seismic dynamic analysis, such as hydrodynamic effects and nonlinear response. If the applicant uses tests or empirical methods in lieu of analysis for any seismic Category I SSCs, it should provide the testing procedure, load levels, and acceptance bases. If these tests or empirical methods are not complete at the time the COL application is filed, the applicant should describe the implementation program, including milestones. These tests or empirical methods should be submitted to staff for review and approval prior to issuance of license. When a nonlinear analysis is performed, the applicant should provide specific information regarding consideration of inelastic/nonlinear behavior of SSCs.

C.I.3.7.2.2 ***Natural Frequencies and Responses***

When the applicant performs modal time history analyses and/or response spectrum analyses, it should provide the modal properties (natural frequencies, participation factors, mode shapes, modal masses, and percentage of cumulative mass). For all seismic system analyses performed (modal time history analyses and response spectrum analyses), the applicant should provide seismic responses (maximum absolute nodal accelerations, maximum displacement relative to the top of foundation mat, and maximum member forces and moments) for major seismic Category I structures. Also, the applicant should include the in-structure response spectra at major seismic Category I equipment elevations and points of support, generated from the system dynamic response analyses.

C.I.3.7.2.3 ***Procedures Used for Analytical Modeling***

The applicant should describe the types of model (finite element model, lumped-mass stick model, hybrid model, etc.) used for seismic Category I structures. The description should include the criteria and procedures used for modeling in the seismic system analyses and indicate how foundation torsion, rocking, and translation are modeled for the seismic system analyses. The applicant should include criteria and bases used to determine whether a component or structure should be analyzed as part of a system analysis or independently as a subsystem.

C.I.3.7.2.4 ***Soil-Structure Interaction***

As applicable, the applicant should provide definition and location of the control motion and modeling methods of SSI analysis used in the seismic system analysis, as well as their bases. This section should include information on (1) extent of embedment, (2) depth of soil over bedrock, (3) layering of soil strata, and (4) strain-dependent shear modulus (reduction curves and hysteretic damping ratio relations) appropriate for each layer of the site soil column. If applicable, the applicant should specify the procedures by which strain-dependent soil properties (e.g., hysteretic damping, shear modulus, and pore pressure) and layering are incorporated into the site response analyses used to generate free-field ground motions, as well as how these soil properties are used when the SSI analysis incorporates the variations of soil properties. The applicant should show how the upper and lower bound iterated soil properties used in the SSI analyses are consistent with those generated from the free-field analyses (if necessary, by referencing the information in FSAR Section 3.7.1.3). The discussion should specify the type of soil foundation model (lumped soil spring model, finite element model, etc.). If using the finite element model, the applicant should specify the criteria for determining the location of the bottom and side boundaries of the analysis model as applicable. The applicant should also specify procedures used to account for effects of adjacent structures (through soil structure-to-structure interaction), if any, on structural response in the SSI analysis.

If it is necessary to apply a forcing function at boundaries of the soil foundation model to simulate earthquake motion for performing a dynamic analysis for the soil-structure system, the applicant should discuss the theories and procedures used to generate the forcing function system such that response motion of the soil media in the free field at the site is identical to the design ground motion, and such that these boundary effects do not influence the SSI analyses.

This section should describe the procedures for incorporating strain-dependent soil properties, embedded effects, layering, and variation of soil properties into the analysis. If lumped spring-dashpot methods are used, the discussion should explain the theories and methods for calculating the soil springs and the suitability of such methods for the particular site conditions and the parameters used in the SSI analysis. Also, the applicant should show how the analysis accounts for frequency-dependent soil properties of the lumped spring-dashpot models for different modes of response.

The discussion should include any other methods used for SSI analysis or the basis for not using SSI analysis.

C.I.3.7.2.5 ***Development of Floor Response Spectra***

The applicant should describe the procedures, basis, and justification for developing floor response spectra considering the three components of earthquake motion, two horizontal and one vertical, specified in Regulatory Guide 1.122, "Development of Floor Design Response Spectra Seismic Design of Floor-Supported Equipment or Components." If using a single artificial time history analysis method to develop floor response spectra, the applicant should demonstrate that (1) provisions of Regulatory Guide 1.122, including peak broadening requirements, apply, (2) response spectra of the artificial time history to be employed in the free field envelop the free-field design response spectra for all damping values actually used in the response spectra, and (3) the PSD generated from the time history envelops the target power spectral density. If the applicant applies multiple time histories to generate floor response spectra, it should provide the basis for the methods used to account for uncertainties in parameters. If the applicant uses a modal response spectrum analysis method to develop floor response spectra, it should provide the basis for the method's conservatism and equivalence to a time history method.

For COL plants, the discussion of PSHA in Section C.I.3.7.1.1.1 applies.

C.I.3.7.2.6 ***Three Components of Earthquake Motion***

The applicant should indicate the extent to which procedures for considering the three components of earthquake motion in determining seismic response of SSCs conform with Regulatory Guide 1.92, "Combining Modal Responses and Spatial Components in Seismic Response Analysis," Revision 2, and provide suitable justifications for any exceptions to this guidance.

C.I.3.7.2.7 ***Combination of Modal Responses***

When the applicant uses a modal time history analysis method and/or a response spectrum analysis method to calculate seismic response of SSCs, it should describe the procedure for combining modal responses (i.e., shears, moments, stresses, deflections, and accelerations), including that for modes with closely spaced frequencies. Also, the description should indicate the extent to which the applicant has followed the recommendations of Regulatory Guide 1.92, Revision 2, including those applicable to adequate consideration of high-frequency modes to combine modal responses.

C.I.3.7.2.8 ***Interaction of Non-Seismic Category I Structures with Seismic Category I Structures***

This section should describe the location of all plant structures (seismic Category I, seismic Category II, and nonseismic structures), including the distance between structures and the height of each structure. The description should provide the design criteria used to account for seismic motion of non-seismic Category I (seismic Category II and nonseismic) structures, or portions thereof, in the seismic design of seismic Category I structures or parts thereof. The applicant should describe the seismic design of non-seismic Category I structures whose continued function is not required, but whose failure could adversely affect the safety function of SSCs or result in incapacitating injury to control room occupants. The description should include the design criteria that will be applied to ensure protection of seismic Category I structures from structural failure of non-Category I structures as a result of seismic effects.

C.I.3.7.2.9 ***Effects of Parameter Variations on Floor Response Spectra***

This section should describe the procedures that the applicant will use to consider effects of expected variations of structural properties, damping values, soil properties, and uncertainties attributable to modeling of soil structure systems on floor response spectra and time histories.

C.I.3.7.2.10 ***Use of Constant Vertical Static Factors***

Where applicable, the applicant should identify and justify the application of equivalent static factors as vertical response loads for the seismic design of seismic Category I SSCs in lieu of using the response loads generated from a vertical seismic system dynamic analysis method.

C.I.3.7.2.11 ***Method Used To Account for Torsional Effects***

The applicant should describe the method used to consider torsional effects in the seismic analysis of seismic Category I structures, including evaluation and justification of static factors or any other approximate methods used (in lieu of a combined vertical, horizontal, and torsional system dynamic analysis) to account for torsional accelerations in seismic design of seismic Category I structures. Also, the applicant should describe the method used to consider the torsional effects attributable to accidental eccentricities for each seismic Category I structure.

C.I.3.7.2.12 ***Comparison of Responses***

Where the applicant uses both response spectrum analysis and time history analysis methods, it should provide the responses obtained from both methods at selected points in major seismic Category I structures, together with a discussion comparing the responses.

C.I.3.7.2.13 ***Methods for Seismic Analysis of Dams***

The applicant should describe the analytical methods and procedures to be used for seismic analysis of seismic Category I concrete dams, including assumptions made, models developed, boundary conditions used, analysis methods used, hydrodynamic effects considered, and procedures by which the analysis incorporates strain-dependent material properties of foundations.

C.I.3.7.2.14 ***Determination of Dynamic Stability of Seismic Category I Structures***

The applicant should describe the dynamic methods and procedures used to determine dynamic stability (overturning, sliding, and floatation) of seismic Category I structures.

C.I.3.7.2.15 ***Analysis Procedure for Damping***

The applicant should describe the procedure used to account for damping in various elements of a soil-structure system model.

C.I.3.7.3 **<u>Seismic Subsystem Analysis</u>**

This section of the FSAR covers civil structure-related subsystems such as platforms, trusses, buried piping, conduit, tunnels, dams, dikes, aboveground tanks, and the like. Section C.I.3.9.2 of this guide covers the seismic analysis of mechanical subsystems (such as piping, mechanical components, and nuclear steam supply systems).

C.I.3.7.3.1 ***Seismic Analysis Methods***

This section should describe analysis methods to be used for seismic analysis of seismic Category I subsystems. The applicant should provide the information requested in Section C.I.3.7.2.1, but apply it to seismic Category I subsystems. The description should include the basis for using the equivalent static load method of analysis, if applicable, and the procedures for determining equivalent static loads.

C.I.3.7.3.2 ***Procedures Used for Analytical Modeling***

This section should provide the criteria and procedures used for modeling seismic subsystems. The applicant should confirm the use of criteria and bases described in Section C.I.3.7.2.3 to determine whether a component or structure should be independently analyzed as a subsystem.

C.I.3.7.3.3 ***Analysis Procedure for Damping***

This section should provide the information requested in Section C.I.3.7.2.15 but as it pertains to seismic Category I subsystems.

C.I.3.7.3.4 ***Three Components of Earthquake Motion***

The applicant should provide the information requested in Section C.I.3.7.2.6 but as it pertains to seismic Category I subsystems.

C.I.3.7.3.5 ***Combination of Modal Responses***

The applicant should provide the information requested in Section C.I.3.7.2.7 but as it pertains to seismic Category I subsystems.

C.I.3.7.3.6 ***Use of Constant Vertical Static Factors***

The applicant should provide the information requested in Section C.I.3.7.2.10 but as it pertains to seismic Category I subsystems.

C.I.3.7.3.7 ***Buried Seismic Category I Piping, Conduits, and Tunnels***

This section should describe seismic criteria and methods for considering effects of earthquakes on buried piping, conduits, tunnels, and auxiliary systems. These criteria include compliance characteristics of soil media; dynamic pressures; seismic wave passage; and settlement attributable to earthquake and differential movements at support points, penetrations, and entry points into other structures provided with anchors.

C.I.3.7.3.8 ***Methods for Seismic Analysis of Category I Concrete Dams***

The applicant should describe the analytical methods and procedures to be used for seismic analysis of seismic Category I concrete dams, including assumptions made, models developed, boundary conditions used, analysis methods used, hydrodynamic effects considered, and procedures by which the analysis incorporates strain-dependent material properties of foundations.

C.I.3.7.3.9 ***Methods for Seismic Analysis of Aboveground Tanks***

The applicant should provide seismic criteria and analysis methods that consider hydrodynamic forces, tank flexibility, SSI, and other pertinent parameters for seismic analysis of seismic Category I aboveground tanks.

C.I.3.7.4 **<u>Seismic Instrumentation</u>**

This section should discuss the proposed instrumentation system for measuring the effects of an earthquake.

C.I.3.7.4.1 ***Comparison with Regulatory Guide 1.12***

The applicant should discuss the proposed seismic instrumentation program and compare it with the seismic instrumentation guidelines of Regulatory Guide 1.12, "Instrumentation for Earthquakes." The applicant should provide the bases for elements of the proposed seismic instrumentation program that differ from those recommended in that regulatory guide.

C.I.3.7.4.2 ***Location and Description of Instrumentation***

This section should describe locations of seismic instrumentation such as triaxial peak accelerographs, triaxial time history accelerographs, and triaxial response spectrum recorders that will be installed in selected seismic Category I structures and components. The description should specify the bases for selection of the seismic instrumentation and installation locations and discuss the extent to which the instrumentation will be used to verify seismic analyses following an earthquake.

C.I.3.7.4.3 ***Control Room Operator Notification***

This section should describe the procedures to be followed to inform the control room operator of the peak acceleration level, cumulative absolute velocity, and input response spectra values shortly after occurrence of an earthquake. It should include the bases for establishing predetermined values for activating the readout of the seismic instrumentation to the control room operator.

C.I.3.7.4.4 ***Comparison with Regulatory Guide 1.166***

The applicant should discuss the response procedure immediately after an earthquake and compare it with Regulatory Guide 1.166, "Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Post-Earthquake Actions." The discussion should include the bases for elements of the response procedure that differ from those of the guidelines in Regulatory Guide 1.166. Provide suitable justification for any exceptions/deviations from guidance in Regulatory Guide 1.166.

C.I.3.7.4.5 *Instrument Surveillance*

The applicant should discuss requirements for instrument surveillance testing and calibration pertaining to instrument operability and reliability.

C.I.3.7.4.6 *Program Implementation*

If the details of the seismic instrumentation implementation plan are not available at the time the COL application is prepared, the applicant should provide sufficient detail for the staff to be able to assess the adequacy of the program implementation

C.I.3.8 *Design of Category I Structures*

C.I.3.8.1 Concrete Containment

This section should provide the following information on concrete containments and on concrete portions of steel/concrete containments:

(1) physical description
(2) applicable design codes, standards, and specifications
(3) loading criteria, including loads and load combinations
(4) design and analysis procedures
(5) structural acceptance criteria
(6) materials, quality control programs, and special construction techniques
(7) testing and inservice inspection programs, including milestones

C.I.3.8.1.1 Description of the Containment

The applicant should define the primary structural aspects and elements relied on to perform the containment function by providing a physical description of the concrete containment or concrete portions of steel/concrete containment, including plan and section views. The description should include the geometry of the concrete containment or concrete portions of steel/concrete containments, including plan views at various elevations and sections in at least two orthogonal directions. The applicant should describe the arrangement of the containment and the relationship and interaction of the containment structure with its surrounding structures and with its interior compartments. The discussion should also explain the effect these structures have on the design boundary conditions and expected structural behavior of the containment when subjected to design loads. The applicant should provide general descriptions of the following:

(1) base foundation including reinforcement, the anchorage and stiffening system, and methods for anchoring the interior structures

(2) containment structure wall, including the main reinforcement and prestressing tendons, and its anchorage and stiffening system; the major penetrations and the reinforcement surrounding them; and major structural attachments to the wall that penetrate the containment structure or any attachment to the containment structure wall to support external structures

(3) for the containment structure, the main reinforcement and prestressing tendons; its anchorage and stiffening system; and any major attachments made from the inside

(4) applicable structural features, such as containment refueling seals and drains, seismic gaps between adjacent structural elements, rock anchors, subfoundation draining system, and containment settlement monitoring system

In FSAR Section 3.8.2, provide a discussion of steel components of concrete containments that resist pressure and are not backed by structural concrete.

C.I.3.8.1.2 ***Applicable Codes, Standards, and Specifications***

The applicant should provide design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards used in the design, fabrication, construction, testing, and inservice inspection of the containment. For each document, the applicant should identify the specific edition, date, or addenda.

C.I.3.8.1.3 ***Loads and Load Combinations***

The applicant should discuss loads and load combinations utilized in the design of the containment structure, with emphasis on the extent of compliance with Article CC-3000 of the ASME Boiler and Pressure Vessel Code (hereafter referred to as the ASME Code), Section III, Division 2, "Code for Concrete Reactor Vessels and Containment," and/or the specific edition, date, or addenda of design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards. Those normally applicable to concrete containment include the following:

(1) loads encountered during preoperational testing

(2) loads encountered during normal plant startup, operation, and shutdown, including dead loads, live loads, thermal loads attributable to operating temperature, hydrostatic loads, and hydrodynamic loads

(3) loads sustained in the event of severe environmental conditions, including those induced by the design wind and the OBE

(4) loads sustained during extreme environmental conditions, including those induced by the design-basis tornado and the SSE

(5) loads sustained during abnormal plant conditions, including the design-basis loss-of-coolant accident (LOCA)

(6) loads imposed by other postulated accidents such as high-energy pipe ruptures, with associated elevated temperature effects and pressure and localized loads such as jet impingement and associated missile impact

(7) external pressure loads generated by events inside or outside the containment

(8) loads encountered and sustained after abnormal plant conditions, such as flooding of the containment subsequent to a LOCA

(9) for those plants to which 10 CFR 50.34(f)(3)(v) applies, loads generated as a result of an inadvertent full actuation of a postaccident inerting hydrogen control system (assuming carbon dioxide) but not including seismic or design-basis accident loadings (see 10 CFR 50.34(f)(3)(v)(B)(1))

(10) for those plants to which 10 CFR 50.34(f)(3)(v) applies, pressure and dead loads alone during an accident that releases hydrogen generated from 100% fuel clad metal-water reaction and accompanied by either hydrogen burning or added pressure from post-accident inerting (see 10 CFR 50.34(f)(3)(v)(A)(1)).

The applicant should discuss various combinations of the above loads that are normally postulated, such as normal operating loads with severe environmental and abnormal loads, and post-LOCA flooding loads with severe environmental loads.

The discussion should include any other site-related or plant-related loads and load combinations applicable to the containment. Examples of such loads include those induced by floods, potential aircraft crashes, explosive hazards in proximity to the site, and missiles generated from activities of nearby military installations or turbine failures.

C.I.3.8.1.4 ***Design and Analysis Procedures***

The applicant should describe the design and analysis method used for the containment, including key assumptions and the basis for selection of structural models and boundary conditions, with emphasis on the extent of compliance with Article CC-3000 of the ASME Code, Section III, Division 2, and/or specific edition, date, or addenda of design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards. The discussion should include loads such as axissymmetric, nonaxisymmetric, localized, or transient and provide analysis and design of concrete characteristics such as creep and shrinkage. It should reference all computer programs used to permit identification with available published programs and describe proprietary computer programs in sufficient detail to establish their applicability and the method for validating them. The applicant should discuss the effects of seismic tangential (membrane) shears and provide analysis results of the effects of expected variation in assumptions and material properties. The description should include the method of analyzing large thickened penetration regions and their effect on the containment behavior. The applicant should provide the analysis and design methods for the containment wall and its anchorage system.

C.I.3.8.1.5 ***Structural Acceptance Criteria***

The applicant should specify the acceptance criteria relating to stresses, strains, gross deformations, and other parameters that quantitatively identify margins of safety, with emphasis on the extent of compliance with Article CC-3000 of the ASME Code, Section III, Division 2, and/or to the specific edition, date, or addenda of design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards. The applicant should provide information to address the containment as an entire structure and also the margins of safety related to the major important local areas of the containment, including openings, anchorage zones, and other areas important to the safety function. The applicant should address the various loading combinations in terms of allowable limits for at least the following major parameters:

(1) compressive stresses in concrete, including membrane, membrane plus bending, and localized stresses

(2) shear stresses in concrete

(3) tensile stresses in reinforcement

(4) tensile stresses in prestressing tendons

(5) tensile or compressive stress/strain limits in the liner plate, including membrane and membrane plus bending

(6) force/displacement limits in the containment structure anchors, including those induced by strains in the adjacent concrete

C.I.3.8.1.6 ***Materials, Quality Control, and Special Construction Techniques***

The applicant should identify materials used in the construction of the containment, with emphasis on the extent of compliance with Article CC-2000 of the ASME Code, Section III, Division 2, and/or to the specific edition, date, or addenda of design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards. This section should also include a summary of the engineering properties of the materials of construction, such as the following:

(1) concrete ingredients
(2) reinforcing bars and splices
(3) prestressing system
(4) liner plate
(5) liner plate anchors and associated hardware
(6) structural steel used for embedment, such as beam seats and crane brackets
(7) corrosion-retarding compounds

The applicant should describe the quality control program for containment fabrication and construction, with emphasis on the extent of compliance with Articles CC-4000 and CC-5000 of the ASME Code, Section III, Division 2, and/or the specific edition, date, or addenda of design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards. The description should include the extent to which the quality control program covers the examination of materials, including tests to determine the physical properties of material and the combination of materials used for construction. It should also describe the extent to which the quality control program covers the examination of placement of material, erection tolerances, reinforcement, and the prestressing system.

The applicant should also identify and describe special, new, or unique construction techniques and the effects that those techniques may have on the structural integrity of the completed containment.

The section should include an identification and description of the detailed program for the use of grouted tendons for the containment structure and indicate the extent to which the program follows the recommendations of Regulatory Guide 1.107, "Qualifications for Cement Grouting for Pre-stressing Tendons in Containment Structures." The applicant should provide suitable justifications for any exceptions to this guidance.

C.I.3.8.1.7 ***Testing and Inservice Inspection Requirements***

The applicant should describe the testing and inservice inspection program, including milestones, for the containment, with emphasis on the extent of compliance with Articles CC-6000 and CC-9000 of the ASME Code, Section III, Division 2, and/or the specific edition, date, or addenda of design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards, and the extent to which the testing and inservice inspection program follow the recommendations of Regulatory Guide 1.18, "Structural Acceptance Test for Concrete Primary Reactor Containment"; Regulatory Guide 1.35, "Inservice Inspection of Ungrouted Tendons in Prestressed Concrete Containment Structures"; and Regulatory Guide 1.90, "Inservice Inspection of Prestressed Concrete Containment Structures with Grouted Tendons." The discussion should cover the initial structural integrity testing, as well as those tests related to the inservice inspection programs and requirements. The applicant should provide information on the technical specification pertaining to the incorporation of inservice inspection programs. Additionally, the applicant should define the objectives of the tests, as well as the acceptance criteria for the results, and discuss the extent of additional testing and inservice inspection, including milestones, if it is using new or previously untried design approaches.

C.I.3.8.2 <u>Steel Containment</u>

The applicant should provide information similar to that requested in Section C.I.3.8.1 of this guide, but the information should pertain to steel containment and Class MC (see ASME Code, Section III, Subsection NE) vessels, parts, or appurtenances of steel or concrete containment. The information described below is particularly important.

C.I.3.8.2.1 *Description of the Containment*

The applicant should provide a physical description of the steel containment and other Class MC components and supplement the description with plan and section views sufficient to define the primary structural aspects and elements relied on to perform the containment or other Class MC component function.

The description should include the geometry of the containment or component, including plan views at various elevations and sections in at least two orthogonal directions. The applicant should also describe the arrangement of the containment structure, particularly the relationship and interaction of the containment structure with its surrounding structures and with its interior compartments and floors, to establish the effect that these structures could have on the design boundary conditions and expected behavior of the containment structure when subjected to the design loads. The description should include the following general information related to cylindrical containment structures:

(1) the foundation of the steel containment

   (a) If the bottom of the steel containment is continuous, describe the method by which this containment structure and its supports are anchored to the concrete foundation. Describe the foundation in FSAR Section 3.8.5.

   (b) If the bottom of the steel containment is not continuous, and if a concrete base slab covered with a liner plate is used for a foundation, describe the method of anchorage of the steel containment structure walls in the concrete base slab, particularly the connection between the floor liner plate and the steel containment structure. Describe the concrete foundation in FSAR Section 3.8.1.

(2) any major structural attachments, such as beam seats, pipe restraints, crane brackets, and shell stiffeners in the hoop and vertical directions

(3) the dome of the steel containment structure, including any reinforcement at the dome/wall junction, penetrations or attachments on the inside, such as supports for containment spray piping, and any stiffening of the dome

(4) major penetrations of steel or concrete containment, or portions thereof (in particular, portions of the penetrations that are intended to resist pressure, but are not backed by concrete, such as fuel transfer tubes, electrical penetrations, and access openings such as personnel locks)

(5) applicable structural features, such as containment refueling seals and drains, seismic gaps between adjacent structural elements, rock anchors, the subfoundation draining system, and the containment settlement monitoring system

The applicant should provide similar information for containment structures that are not cylindrical.

C.I.3.8.2.2 ***Applicable Codes, Standards, and Specifications***

This section should provide information similar to that requested for concrete containment in Section C.I.3.8.1.2 of this guide, but as applicable to steel containment or other Class MC components.

C.I.3.8.2.3 ***Loads and Load Combinations***

The applicant should specify the loads used in the design of the steel containment or other Class MC components, with emphasis on the extent of compliance with Article NE-3000 of the ASME Code, Section III, Division 1, "Class 3 Components," and/or the specific edition, date, or addenda of design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards, and the extent to which the loads and load combinations follow the recommendations of Regulatory Guide 1.57, "Design Limits and Loading Combinations for Metal Primary Reactor Containment System Components." This section should include the following:

(1) loads encountered during preoperational testing

(2) loads encountered during normal plant startup, operation, and shutdown, including dead loads, live loads, thermal loads attributable to operating temperature, hydrostatic loads, and hydrodynamic loads

(3) loads sustained in the event of severe environmental conditions, including those induced by the design wind and the OBE

(4) loads sustained in the event of extreme environmental conditions, including those that would be induced by the design-basis tornado and the SSE

(5) loads sustained in the event of abnormal plant conditions, including the design-basis LOCA

(6) loads induced by other postulated accidents such as high-energy pipe ruptures with associated elevated temperature effects, pressures, and possible localized impact loads such as jet impingement and associated missile impact

(7) external pressure loads generated by events inside or outside the containment

(8) loads encountered and sustained after abnormal plant conditions, including flooding of the containment

(9) loads generated as a result of an inadvertent full actuation of a postaccident inerting hydrogen control system (assuming carbon dioxide) but not including seismic or design-basis accident loadings (see 10 CFR 50.34(f)(3)(v)(B)(1))

(10) pressure and dead loads alone during an accident that releases hydrogen generated from 100 percent fuel clad metal-water reaction and accompanied by either hydrogen burning or added pressure from postaccident inerting (see 10 CFR 50.34(f)(3)(v)(A)(1))

The applicant should discuss various combinations of the above loads that are normally postulated, such as normal operating loads with extreme environmental loads and abnormal loads.

As explained in Section C.I.3.8.1.3 of this guide, the discussion should include any other site-related or plant-related design loads that may be applicable.

C.I.3.8.2.4 ***Design and Analysis Procedures***

The applicant should describe the design and analysis method used, including key assumptions and the basis for selection of structural models and boundary conditions for the steel containment, with emphasis on the extent of compliance with Subsection NE of the ASME Code, Section III, Division 1, as augmented by applicable provisions of Regulatory Guide 1.57, and/or the specific edition, date, or addenda of design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards. In particular, the discussion should include (1) treatment of local buckling effects, (2) the expected behavior under loads, including nonaxisymmetric and localized loads, and (3) the computer programs utilized. The applicant should reference these computer programs to permit identification with available published programs and describe proprietary computer programs in sufficient detail to establish their applicability and the method for validating them.

C.I.3.8.2.5 ***Structural Acceptance Criteria***

This section should specify the acceptance criteria related to allowable stresses, strains and gross deformation, and other response characteristics that quantitatively identify the structural behavior of the containment, with emphasis on the extent of compliance with Subsection NE of the ASME Code, Section III, Division 1, and/or the specific edition, date, or addenda of design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards, and the extent to which the structural acceptance criteria follow the recommendations of Regulatory Guide 1.57. The applicant should specify and address the various loading combinations in terms of allowable limits for at least the following major parameters:

(1) primary stresses, including general membrane, local membrane, and bending plus local membrane stresses

(2) primary and secondary stresses

(3) peak stresses

(4) buckling criteria

C.I.3.8.2.6 ***Materials, Quality Control, and Special Construction Techniques***

This section should identify and specify the materials to be used in the construction of the steel containment with emphasis on the extent of compliance with Article NE-2000 of Subsection NE of the ASME Code, Section III, Division 1, and/or the specific edition, date, or addenda of design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards. The applicant should identify major materials such as the following:

(1) steel plates used as containment structure components

(2) structural steel shapes used for stiffeners, beam seats, and crane brackets, including a description of the method for corrosion protection

This section should also describe the quality control program for the fabrication and construction of the containment with emphasis on the extent of compliance with Article NE-5000 of the ASME Code, Section III, Division 1, and/or the specific edition, date, or addenda of design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards, especially for the following:

(1) nondestructive examination of the materials, including tests to determine their physical properties

(2) welding procedures

(3) erection tolerances

The applicant should identify and describe any special construction techniques and potential effects of such techniques on the structural integrity of the completed containment.

C.I.3.8.2.7 ***Testing and Inservice Inspection Requirements***

The applicant should describe the containment testing and inservice inspection programs, including milestones, with emphasis on the extent of compliance with Article NE-6000 of Subsection NE of the ASME Code, Section III, Division 1, and/or the specific edition, date, or addenda of design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards. The discussion should address the proposed initial structural testing, including the objectives of the test, and specify the acceptance criteria for the results. The applicant should also discuss the extent of additional testing and inservice inspection, including milestones, if it is using new or previously untried design approaches. The applicant should provide the criteria for testing the structural integrity for components of the containment such as personnel and equipment locks and submit test program criteria for any other components relied on for containment integrity. The applicant should also provide programs for inservice inspection in areas subject to corrosion.

C.I.3.8.3 **Concrete and Steel Internal Structures of Steel or Concrete Containment**

The applicant should provide information similar to that requested in Section C.I.3.8.1, but for internal structures of the containment. The containment internal structures are those concrete and steel structures that are inside (not part of) the containment pressure boundary and support the reactor coolant system components and related piping systems and equipment. The following subsections describe the recommended information.

C.I.3.8.3.1 ***Description of the Internal Structures***

The applicant should define the primary structural aspects and elements relied on to perform the safety-related functions by including a physical description of the internal structures, including plan and section views. This description should contain general arrangement diagrams and principal features of major internal structures. The major structures to be described include the following:

(1) for pressurized-water reactor containment

- (a) reactor support system
- (b) steam generator support system
- (c) reactor coolant pump support system
- (d) primary shield wall and reactor cavity
- (e) secondary shield walls
- (f) other major internal structures, such as supports, the refueling cavity walls, in-containment refueling water storage tank, the operating floor, intermediate floors, and various platforms

(2) for boiling-water reactor (BWR) containment

  (a) drywell structure and appurtenances such as the drywell head and major penetrations

  (b) weir wall

  (c) refueling pool and operating floor

  (d) reactor and recirculating pump and motor support system

  (e) reactor pedestal

  (f) reactor shield wall

  (g) other major interior structures, as appropriate, including the various platforms inside and outside the drywell

C.I.3.8.3.2 ***Applicable Codes, Standards, and Specifications***

The applicant should provide information similar to that requested for concrete containment in Section C.I.3.8.1.2 of this guide and Regulatory Guide 1.142, but the information should pertain to the containment internal structures listed in FSAR Section 3.8.3.1.

C.I.3.8.3.3 ***Loads and Load Combinations***

The applicant should discuss and specify the loads used in the design of the containment internal structures listed in FSAR Section 3.8.3.1. At a minimum, the discussion should include the following:

(1) loads encountered during normal plant startup, operation, and shutdown, including dead loads, live loads, thermal loads attributable to operating temperature, hydrostatic loads, and hydrodynamic loads

(2) loads sustained in the event of severe environmental conditions, including those induced by the OBE

(3) loads sustained in the event of extreme environmental conditions, including those that would be induced by the SSE

(4) loads sustained in the event of abnormal plant conditions, including LOCAs

(5) loads resulting from other postulated accidents, such as high-energy pipe ruptures with associated elevated temperature effects, pressures, and possible other localized impacts

The applicant should discuss the various combinations of the above loads that are usually postulated, such as normal operating loads, normal operating loads with severe environmental loads, and normal operating loads with extreme environmental loads and abnormal loads.

The applicant should provide specific information, emphasizing the following considerations:

(1) the extent to which the criteria comply with ACI-349, "Proposed ACI Standard: Code Requirements for Nuclear Safety Related Concrete Structures," for concrete, and with the American National Standards Institute/American Institute of Steel Construction (ANSI/AISC) N690 (1994), "Specification for Design, Fabrication and Erection of Structural Steel for Buildings,"[1] including Supplement 2 (2004), for steel, and/or the specific edition, date, or

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[1] The structures listed are those of the BWR Mark III containment. For other BWR containment concepts, the applicant should describe the major interior structures in the same manner.

addenda of design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards

(2) for concrete pressure-resisting portions of the structure, the extent to which the criteria comply with Article CC-3000 of the ASME Code, Section III, Division 2, and/or the specific edition, date, or addenda of design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards

(3) for steel pressure-resisting portions of the structures described in item 2 above, the extent to which the applicant's criteria comply with Article NE-3000 of Subsection NE of the ASME Code, Section III, Division 1; the recommendations of Regulatory Guide 1.57; and/or the specific edition, date, or addenda of design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards

(4) for steel linear supports, the extent to which the applicant's criteria comply with Subsection NF of the ASME Code, Section III, Division 1, augmented by Regulatory Guide 1.57 and/or the specific edition, date, or addenda of design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards

C.I.3.8.3.4 ***Design and Analysis Procedures***

The applicant should describe the design and analysis method and assumptions and identify the boundary conditions of those internal structures listed in FSAR Section 3.8.3.1. The description should include the expected behavior under load and the mechanisms for load transfer to these structures and then to the containment base. The applicant should reference the computer programs utilized to permit identification with available published programs and describe proprietary computer programs in sufficient detail to establish their applicability and the method for validating them.

This section should specify the extent to which the design and analysis procedures comply with ACI-349 and with the AISC specifications for concrete and steel structures, respectively, and/or the specific edition, date, or addenda of design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards.

The description should include the design and analysis method used with the assumptions regarding boundary conditions, for reactor coolant system linear supports. It should also specify and identify the type of analysis (elastic or plastic) and the methods of load transfer, particularly seismic and accident loads. The applicant should specify the extent of compliance with design and analysis procedures delineated in Subsection NF of the ASME Code, Section III, Division 1, and/or the specific edition, date, or addenda of design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards.

The applicant should describe the design and analysis method utilized for reactor primary shield walls, including the method for transfer of the individual loads and load combinations to the walls and their foundations. The description should include the normal operating thermal gradient, if any, and seismic loads and accident loads, as they may act on the entire cavity or portions thereof.

The applicant should describe the design and analysis method utilized, including assumptions for secondary shield walls and operating and intermediate floors on structural framing and behavior under loads. The description should include the method and assumptions, with particular emphasis on modeling techniques, boundary conditions, and force-time functions where elastoplastic behavior is assumed and the ductility of the walls is relied on to absorb the energy associated with jet and missile loads. The section should also describe the methods of ensuring elastic behavior for the differential pressure, particularly in determining an equivalent static load for the impulsive pressure load.

For concrete pressure-resisting portions of the containment, the applicant should discuss the extent to which the criteria comply with Article CC-3000 of the ASME Code, Section III, Division 2. For steel pressure-resisting portions of containment, the discussion should address the extent to which the criteria comply with Article NE-3000 of Subsection NE of the ASME Code, Section III, Division 1, as well as the extent to which the criteria follow the recommendations of Regulatory Guide 1.57.

C.I.3.8.3.5 ***Structural Acceptance Criteria***

The applicant should provide information similar to that requested for concrete containment in Section C.I.3.8.1.5 of this guide, but the information should pertain to the various containment internal structures listed in FSAR Section 3.8.3.1.

C.I.3.8.3.6 ***Materials, Quality Control, and Special Construction Techniques***

The applicant should identify and describe the materials, quality control programs, and any special construction techniques. The description should include the major materials of construction, such as the concrete ingredients, reinforcing bars and splices, and the structural steel and various supports and anchors.

The applicant should also describe the quality control program proposed for the fabrication and construction of the containment interior structures, including nondestructive examination of the materials to determine physical properties, placement of concrete, and erection tolerances. This section of the application should also identify and describe special, new, or unique construction techniques to determine their effects on the structural integrity of the completed interior structure.

The applicant should provide the following information:

(1) the extent to which the material and quality control requirements comply with ACI-349 for concrete and with the AISC specifications for steel, as applicable

(2) for steel linear supports of the reactor coolant system, the extent to which the material and quality control requirements comply with Subsection NF of the ASME Code, Section III, Division 1

(3) for quality control in general, the extent of compliance with applicable provisions of SRP Sections 3.8 and 17.5 and recommendations of Regulatory Guide 1.55, "Concrete Placement in Category I Structures"

(4) for welding of reinforcing bars, the extent to which the design complies with the ASME Code, Section III, Division 2 (with identification and justification of any exceptions)

C.I.3.8.3.7 ***Testing and Inservice Inspection Requirements***

The applicant should describe the testing and inservice inspection programs, including milestones, for the internal structures. The description should specify test requirements for internal structures related directly and critically to the functioning of the containment, as well as the inservice inspection requirements. As requested in Section C.I.3.8.3.6 of this guide, the applicant should identify the extent of compliance with the specific edition, date, or addenda of design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards.

C.I.3.8.4 Other Seismic Category I Structures

The applicant should provide information for all seismic Category I structures not covered by Sections C.I.3.8.1, C.I.3.8.2, C.I.3.8.3, or C.I.3.8.5 of this guide. The information provided should be similar to that requested in Section C.I.3.8.1 of this guide.

C.I.3.8.4.1 *Description of the Structures*

This section should contain descriptive information, including plan and section views of each structure, to define the primary structural aspects and elements relied on for the structure to perform its safety-related function. The applicant should describe the relationship between adjacent structures, including any separation or structural ties, and describe the plant's seismic Category I structures, especially the following:

(1) containment enclosure buildings

(2) auxiliary buildings

(3) fuel storage buildings

(4) control buildings

(5) diesel generator buildings

(6) other seismic Category I structures, such as pipe and electrical conduit tunnels, waste storage facilities, stacks, intake structures, pumping stations, water wells, cooling towers, and concrete dams, embankments, and tunnels.

The applicant should also describe structures that are safety-related but, because of other design provisions, are not classified as seismic Category I.

C.I.3.8.4.2 *Applicable Codes, Standards, and Specifications*

The applicant should provide information similar to that requested in Section C.I.3.8.1.2 of this guide for concrete containment, but the information should pertain to all other seismic Category I structures.

C.I.3.8.4.3 *Loads and Load Combinations*

The applicant should specify and identify the loads used in the design of all other seismic Category I structures including the following:

(1) loads encountered during normal plant startup, operation, and shutdown, including dead loads, live loads, thermal loads attributable to operating temperature, and hydrostatic loads such as those in spent fuel pools

(2) loads sustained in the event of severe environmental conditions, including those induced by the OBE and the design wind specified for the plant site

(3) loads sustained in the event of extreme environmental conditions, including those induced by the SSE and the design-basis tornado specified for the plant site

(4) loads sustained during abnormal plant conditions, such as rupture of high-energy piping with associated elevated temperatures and pressures within or across compartments and possibly jet impingement and impact forces

The discussion should cover the various combinations of the above loads that are usually postulated, such as normal operating loads, normal operating loads with severe environmental loads, normal operating loads with extreme environmental loads, normal operating loads with abnormal loads, normal operating loads with severe environmental loads and abnormal loads, and normal operating loads with extreme environmental loads and abnormal loads.

The loads and load combinations described above are generally applicable to most structures. The discussion should include other site-related design loads, such as those induced by floods, potential aircraft crashes, explosive hazards in proximity to the site, and projectiles and missiles generated from activities of nearby military installations.

C.I.3.8.4.4 ***Design and Analysis Procedures***

The applicant should describe the design and analysis method, with assumptions regarding boundary conditions and emphasis on the extent of compliance with ACI-349 and the AISC specifications for concrete and steel structures, respectively. The description should include the expected behavior under load and the mechanisms of load transfer to the foundations. The applicant should reference computer programs to permit identification with available published programs and describe proprietary computer programs to the maximum extent practical to establish the applicability of the programs and the method used to validate them.

C.I.3.8.4.5 ***Structural Acceptance Criteria***

The applicant should specify the design criteria related to stresses, strains, gross deformations, factors of safety, and other parameters that quantitatively identify the margins of safety with an emphasis on the extent of compliance with ACI-349 for concrete, and the ANSI/AISC N690 (1994), including Supplement 2 (2004), specifications for steel, and/or the specific edition, date, or addenda of design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards.

C.I.3.8.4.6 ***Materials, Quality Control, and Special Construction Techniques***

This section should address the materials and quality control programs and identify any new or special construction techniques, as outlined in Section C.I.3.8.3.6 of this guide.

C.I.3.8.4.7 ***Testing and Inservice Inspection Requirements***

This section should specify any testing and inservice inspection requirements.

C.I.3.8.5 **Foundations**

The applicant should provide information similar to that requested in Section C.I.3.8.1 of this guide for concrete containment, but the information should pertain to the foundations of all seismic Category I structures. As appropriate, this section, as well as FSAR Section 3.8.1, should discuss concrete foundations of steel or concrete containment.

The applicant should provide information for foundations for all seismic Category I structures constructed of materials other than soil for the purpose of transferring loads and forces to the basic supporting media.

C.I.3.8.5.1 ***Description of the Foundations***

The applicant should provide descriptive information, including plan and section views of each foundation, to define the primary structural aspects and elements relied on to perform the foundation function. The description should include the relationship between adjacent foundations, including any separation and the reasons for such separation. In particular, the applicant should discuss the type of foundation and its structural characteristics and provide the general arrangement of each foundation, with emphasis on the methods of transferring horizontal shears, such as those that are seismically induced, to the foundation media. If the applicant uses shear keys for such purposes, it should include the general arrangement of the keys. If using waterproofing membranes, the applicant should discuss their effect on the capability of the foundation to transfer shears.

This section should include information to adequately describe other types of foundation structures, such as pile foundations, caisson foundations, retaining walls, abutments, and rock and soil anchorage systems.

C.I.3.8.5.2 ***Applicable Codes, Standards, and Specifications***

This section should provide information similar to that requested in Section C.I.3.8.1.2 of this guide, but as applicable to the foundations of all seismic Category I structures.

C.I.3.8.5.3 ***Loads and Load Combinations***

This section should provide information similar to that requested in Section C.I.3.8.4.3 of this guide, but as applicable to the foundations of all seismic Category I structures.

C.I.3.8.5.4 ***Design and Analysis Procedures***

This section should provide information similar to that requested in Section C.I.3.8.4.4 of this guide, but as applicable to the foundations of all seismic Category I structures.

The applicant should discuss the assumptions regarding boundary conditions, as well as the methods by which lateral loads and forces and overturning moments are transmitted from the structure to the foundation media. The discussion should address the methods for considering the effects of settlement.

C.I.3.8.5.5 ***Structural Acceptance Criteria***

The applicant should provide information similar to that requested in Section C.I.3.8.4.5 of this guide, but as it pertains to the foundations of all seismic Category I structures.

The applicant should describe, and indicate the design limits imposed on, the various parameters that define the structural stability of each structure and its foundations, including differential settlements and factors of safety against overturning and sliding.

C.I.3.8.5.6 ***Materials, Quality Control, and Special Construction Techniques***

This section should provide information similar to that requested in Section C.I.3.8.4.6 of this guide for the foundations of all seismic Category I structures.

C.I.3.8.5.7 ***Testing and Inservice Inspection Requirements***

The applicant should discuss information similar to that requested in Section C.I.3.8.4.7 of this guide for the foundations of all seismic Category I structures.

If programs for continued surveillance and monitoring of foundations are required, the applicant should define the various aspects of the program, including implementation milestones.

C.I.3.9 Mechanical Systems[2] and Components

C.I.3.9.1 **Special Topics for Mechanical Components**

The applicant should provide information concerning the design transients and resulting loads and load combinations with appropriate specified design and service limits for seismic Category I components and supports, including those designated as ASME Code Class 1, 2, 3 (or core support) and those not covered by the ASME Code.

C.I.3.9.1.1 ***Design Transients***

The applicant should provide a complete list of transients used in the design and fatigue analysis of all ASME Code Class 1 and CS components, component supports, and reactor internals. The list should include the number of events for each transient, as well as the number of load and stress cycles per event and for events in combination. The applicant should provide the number of transients assumed for the design life of the plant and describe the environmental conditions to which equipment important to safety will be exposed over the life of the plant (e.g., coolant water chemistry). The applicant should classify all transients (or combinations of transients) with respect to the plant and system operating condition categories identified as "normal," "upset," "emergency," "faulted," or "testing."

C.I.3.9.1.2 ***Computer Programs Used in Analyses***

The applicant should list the computer programs used in dynamic and static analyses to determine the structural and functional integrity of seismic Category I ASME Code and non-ASME Code items and provide the following information:

(1) author, source, dated version, and facility

(2) description and the extent and limitations of the code's applications

(3) demonstration of the computer code's solutions to a series of test problems and the source of the test problems

C.I.3.9.1.3 ***Experimental Stress Analysis***

If the applicant uses experimental stress analysis methods in lieu of analytical methods for seismic Category I ASME Code and non-ASME Code items, it should provide sufficient information to show the validity of the design.

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2 Section 4.2 of the FSAR addresses fuel system design information.

C.I.3.9.1.4 ***Considerations for the Evaluation of the Faulted Condition***

The applicant should describe the analytical methods (e.g., elastic or elastic-plastic) used to evaluate stresses for seismic Category I ASME Code and non-ASME Code components and component support and discuss their compatibility with the type of dynamic system analysis used. The applicant should show that the stress-strain relationship and ultimate strength value used in the analysis for each component is valid. If the applicant invokes the use of elastic or, elastic-plastic component analysis concurrently with elastic or elastic-plastic system analysis, it should show that the calculated component or component support deformations and displacements do not violate the corresponding limits and assumptions on which the method used for the system analysis is based. When elastic-plastic stress or deformation design limits are specified for ASME Code and non-ASME Code components, the applicant should provide the methods of analysis used to calculate the stresses and/or deformations resulting from the faulted condition loadings. The applicant should also describe the procedure for developing the loading function for each component.

C.I.3.9.2 **Dynamic Testing and Analysis of Systems, Components, and Equipment**

The applicant should provide the criteria, testing procedures, and dynamic analyses employed to ensure the structural and functional integrity of piping systems, mechanical equipment, reactor internals, and their supports (including supports for conduit and cable trays and ventilation ducts) under vibratory loadings, including those attributable to flow-induced vibration, acoustic resonance, postulated pipe breaks, and seismic events.

C.I.3.9.2.1 ***Piping Vibration, Thermal Expansion, and Dynamic Effects***

The applicant should provide information concerning the piping vibration, thermal expansion, and dynamic effects testing that it will conduct during startup functional testing on ASME Code Class 1, 2, and 3 systems; other high-energy piping systems inside seismic Category I structures; high-energy portions of systems for which failure could reduce the functioning of any seismic Category I plant feature to an unacceptable level; and seismic Category I portions of moderate-energy piping systems located outside containment. The applicant should show that these tests will demonstrate that the piping systems, restraints, components, and supports have been designed to (1) withstand the flow-induced dynamic loadings under operational transient and steady-state conditions anticipated during service and (2) not restrain normal thermal motion.

The applicant should include the following information concerning the piping vibration, thermal expansion, and dynamic effects testing:

(1) List of the systems that will be monitored.

(2) List of the different flow modes of operation and transients such as pump trips and valve closures to which the components will be subjected during the test. Additional guidance provided in Regulatory Guide 1.68, "Initial Test Programs for Water-Cooled Nuclear Power Plants."

(3) List of the locations selected for visual inspections and measurements in the piping system during the tests. For each of these selected locations, the applicant should include the deflection (peak-to-peak) or other appropriate criteria to show that the stress and fatigue limits are within the design levels. The applicant should also provide the rationale and bases for the acceptance criteria and selection of locations to monitor pipe motions. If the as-built specifics are not available at the time of the COL application, representative and bounding conditions may be used in the analysis to be submitted with the COL application for staff review. The applicant should in the COL application agree on an appropriate method (e.g., ITAAC, license condition, FSAR

update) to ensure that the as-built plant is consistent with the design reviewed during the licensing process.

(4) List of the snubbers on systems that experience sufficient thermal movement to measure snubber travel from cold to hot position. The applicant should in the COL application agree on an appropriate method (e.g., ITAAC, license condition, FSAR update) to ensure that the as-built plant is consistent with the design reviewed during the licensing process.

(5) Description of the thermal motion monitoring program to ensure that clearances are adequate to allow unrestrained normal thermal movement of systems, components, and supports.

(6) Description of the corrective actions that the applicant will take if vibration exceeds acceptable levels, piping system restraints are determined to be inadequate or are damaged, or no snubber piston travel is measured.

(7) If the piping vibration, thermal expansion, and dynamic effects testing is incomplete at the time the COL application is filed, the applicant should specify whether they are part of the initial test program and should describe the implementation program, including milestones.

C.I.3.9.2.2 ***Seismic Analysis and Qualification of Seismic Category I Mechanical Equipment***

The applicant should describe the seismic system analysis and qualification of Category I systems, components, equipment, and their supports (including supports for conduit and cable trays and ventilation ducts) performed to ensure functional integrity and operability during and after a postulated seismic occurrence.

C.I.3.9.2.2.1 **Seismic Qualification Testing**

FSAR Section 3.10 describes the methods and criteria for seismic qualification testing of seismic Category I mechanical equipment.

C.I.3.9.2.2.2 **Seismic System Analysis Methods**

The applicant should describe the seismic analysis methods (e.g., response spectra, time history, equivalent static load) and include the following information in the description:

(1) manner in which the dynamic system analysis is performed

(2) method chosen for selection of significant modes and an adequate number of masses or degrees of freedom

(3) manner in which the seismic dynamic analysis considers maximum relative displacements between supports

(4) other significant effects accounted for in the seismic dynamic analysis, such as piping interactions, externally applied structural restraints, hydrodynamic effects (both mass and stiffness effects), and nonlinear response

If the applicant uses a static load method in lieu of a dynamic analysis, it should provide justification that a simple model can realistically represent the system and that the method produces conservative results.

C.I.3.9.2.2.3 Determination of Number of Earthquake Cycles

The applicant should describe the number of earthquake cycles assumed during one seismic event, the maximum number of cycles for which systems and components are designed, and the criteria used to establish these parameters.

C.I.3.9.2.2.4 Basis for Selection of Frequencies

The applicant should provide the criteria or procedures used to separate fundamental frequencies of components and equipment from the forcing frequencies of the support structure.

C.I.3.9.2.2.5 Three Components of Earthquake Motion

This section should describe how the three components of earthquake motion are considered in determining the seismic response of systems and components.

C.I.3.9.2.2.6 Combination of Modal Responses

When the applicant uses a response spectra method, it should describe how modal responses (e.g., shears, moments, stresses, deflections, and accelerations) were combined, including those for modes with closely spaced frequencies. Additional guidance provided in Regulatory Guide 1.92, "Combining Modal Responses and Spatial Components in Seismic Response Analysis."

C.I.3.9.2.2.7 Analytical Procedures for Piping

The applicant should describe the analytical methods (e.g., response spectra, time history, equivalent static load) used for the seismic analysis of piping systems, including the methods used to consider differential piping support movements at different support points located within a structure and between structures.

C.I.3.9.2.2.8 Multiple-Supported Equipment Components with Distinct Inputs

This section should describe the analytical methods used for the seismic analysis of equipment and components supported at different elevations within a building and between buildings.

C.I.3.9.2.2.9 Use of Constant Vertical Static Factors

Where applicable, the applicant should justify the use of constant static forces instead of vertical seismic system dynamic analysis to compute the vertical response loads for the design of affected systems, components, equipment, and their supports.

C.I.3.9.2.2.10 Torsional Effects of Eccentric Masses

This section should describe the methods used to consider the torsional effects of eccentric masses (e.g., valve operators) in seismic system analyses.

C.I.3.9.2.2.11 Buried Seismic Category I Piping Conduits, and Tunnels

The applicant should describe the seismic criteria and methods used to analyze buried piping, conduits and tunnels, including the procedures used to consider the inertia effects of soil media and the differential displacements at structural penetrations.

C.I.3.9.2.2.12 Interaction of Other Piping with Seismic Category I Piping

This section should describe the seismic analysis methods used to account for the seismic motion of non-seismic Category I piping systems in the seismic design of seismic Category I piping.

C.I.3.9.2.2.13 Analysis Procedure for Damping

This section should describe the criteria used to account for damping in systems, components, equipment, and their supports. Additional guidance provided in Regulatory Guide 1.61, "Damping Values for Seismic Design of Nuclear Power Plants."

C.I.3.9.2.2.14 Test and Analysis Results

The applicant should supply the results of tests and analyses to demonstrate adequate seismic qualification. If the seismic qualification testing is incomplete at the time the COL application is filed, the applicant should describe the implementation program, including milestones.

C.I.3.9.2.3 *Dynamic Response Analysis of Reactor Internals under Operational Flow Transients and Steady-State Conditions*

For a prototype (first of a design) reactor, the applicant should describe the dynamic system analysis and response of the structural components within the reactor vessel caused by operational flow transients and steady-state conditions. The applicant should demonstrate the acceptability of the reactor internals design for normal operating conditions and provide the predicted input forcing functions and the vibratory response of the reactor internals.

This section should also describe analytical methods and procedures to predict vibrations of BWR reactor pressure vessel internals (including the steam dryer) and other main steam system components. The dynamic responses to operational transients and hydrodynamic and acoustic loadings should be determined at locations where sensors would be mounted on the reactor internals (including steam dryers and main steam system components). The discussion should include specific locations for calculated responses, considerations used in defining the mathematical model, interpretations of analytical results, acceptance criteria, and methods of verifying predictions by means of tests.

For a nonprototype reactor, the applicant should provide references to the reactor that is prototypical of the reactor design included in the application, along with a brief summary of test and analysis results.

C.I.3.9.2.4 *Preoperational Flow-Induced Vibration Testing of Reactor Internals*

The applicant should describe the preoperational and startup test program for flow-induced vibration testing of reactor internals and demonstrate that flow-induced vibrations experienced during normal operation will not cause structural failure or degradation.

For a prototype reactor, the applicant should describe flow modes, vibration monitoring sensor types and locations, procedures and methods to be used to process and interpret the measured data, planned visual inspections, planned comparisons of test results with analytical predictions, and possible supplementary tests (e.g., component vibration tests, flow tests, scaled model tests).

For a nonprototype reactor, the applicant should provide references to the reactor that is prototypical of the reactor (design included in the application), along with a brief summary of test and analysis results.

The applicant should identify and justify any deviation from the guidance provided in Regulatory Guide 1.20.

This section should include a detailed analysis of potential adverse flow effects (e.g., flow-induced vibrations and acoustic resonances) that can severely impact BWR reactor pressure vessel internals (including the steam dryer) and other main steam system components that are either different from the designated prototype design or not covered in the prototype test program. Acoustic and computational fluid dynamic analyses and scale model testing should supplement the analysis. The applicant should describe the utilization of instruments on vulnerable components (including pressure, strain, and acceleration sensors on the steam dryer), in addition to satisfying the provisions discussed in FSAR Section 3.9.5 to obtain direct loading data to ensure structural adequacy of the components against the potential adverse flow effects. For a prototype reactor, if the flow-induced vibration testing of reactor internals is incomplete at the time the COL application is filed, the applicant should provide documentation describing the implementation program, including milestones, completion dates and expected conclusions.

C.I.3.9.2.5 *Dynamic System Analysis of the Reactor Internals under Faulted Condition*

The applicant should discuss the dynamic system analysis methods used to confirm the adequacy of the structural design of the reactor internals and the unbroken loop of the reactor piping system, as it relates to withstanding dynamic effects with no loss of function under the simultaneous occurrence of a LOCA or steam line break and SSE.

The applicant should include the following information concerning the dynamic system analysis:

(1) typical diagrams of the dynamic system mathematical modeling of piping, pipe supports, and reactor internals, along with fuel element assemblies and control rod assemblies and drives, used in the analysis and a discussion of the bases for any structural partitioning and directional decoupling of components

(2) methods used to obtain the forcing functions and a description of the forcing functions used for the dynamic analysis of the LOCA or steam line break and SSE event (including system pressure differentials, direction, rise time, magnitude, duration, initial conditions, spatial distribution, and loading combinations)

(3) methods used to compute the total dynamic structural responses, including the buckling response, of those structures in compression

(4) results of the dynamic analysis

C.I.3.9.2.6 *Correlations of Reactor Internals Vibration Tests with the Analytical Results*

The applicant should describe the method used to correlate the results of the reactor internals preoperational vibration test with the analytical results derived from dynamic analyses of reactor internals under operational flow transients and steady-state conditions. The description should include the method used to verify the mathematical model used in the faulted condition (LOCA, steam line break, and SSE) by comparing certain dynamic characteristics such as natural frequencies.

C.I.3.9.3 ASME Code Class 1, 2, and 3 Components, Component Supports, and Core Support Structures

The applicant should discuss the structural integrity of pressure-retaining components, component supports, and core support structures designed and constructed in accordance with the rules of the ASME Code, Section III, Division 1, as well as with GDC 1, 2, 4, 14, and 15. This discussion should also incorporate design information related to component design for steam generators (as requested in Section C.I.5.4.2 of this guide), if applicable, including field run piping and internal parts of components.

C.I.3.9.3.1 *Loading Combinations, System Operating Transients, and Stress Limits*

The applicant should provide the design and service load combinations (e.g., design and service loads, including system operating transients, in combination with loads resulting from postulated seismic and other transient initiating events) specified for components constructed in accordance with the ASME Code and designated as ASME Code Class 1, 2, or 3. This should include Class 1, 2, and 3 component support structures and core support structures to determine that appropriate design and service limits have been designated for all loading combinations. The applicant should describe how actual design and service stress limits and deformation criteria comply with applicable limits specified in the ASME Code. The applicant should provide information on service stress limits that allow inelastic deformation of ASME Code Class 1, 2, and 3 components, component supports, and core support structures and provide justification for proposed design procedures. The discussion should include information on field run piping and internal parts of components (e.g., valve discs and seats and pump shafting) subjected to dynamic loading during operation of the component.

The applicant should include the following information for ASME Code Class 1 components, core support structures, and ASME Code Class 1 component supports:

(1) Summary description of mathematical or test models used.

(2) Methods of calculations or tests, including simplifying assumptions, identification of method of system and component analysis used, and demonstration of their compatibility (see Section C.I.3.9.1.4 of this guide) in the case of components and supports that are designed to faulted limits.

(3) Summary of the maximum total stress, deformation, and cumulative usage factor values for each of the component operating conditions for all ASME Code Class I components. The applicant should identify those values that differ from the allowable limits by less than 10 percent and provide the contribution of each of the loading categories, (e.g., seismic, dead weight, pressure, and thermal) to the total stress for each maximum stress value identified in this range.

The applicant should include the following information for all other classes of components and their supports:

(1) summary description of any test models used (see Section C.I.3.9.1.3 of this guide)

(2) summary description of mathematical or test models used to evaluate faulted conditions, as appropriate, for components and supports (see Sections C.I.3.9.1.2 and C.I.3.9.1.4 of this guide)

(3) for all ASME Code Class 2 and 3 components required to shut down the reactor or mitigate consequences of a postulated piping failure without offsite power, a summary of the maximum total stress and deformation values for each of the component operating conditions (with identification of those values that differ from the allowable limits by less than 10 percent)

The discussion should include a list of transients appropriate to ASME Code Class 1, 2, and 3 components, core support structures, and component supports categorized on the basis of plant operating condition. In addition, for ASME Code Class 1 components, core support structures, and component supports, the applicant should include the number of cycles to be used in the fatigue analysis appropriate to each transient (see Section C.I.3.9.1.1 of this guide).

C.I.3.9.3.2 ***Design and Installation of Pressure-Relief Devices***

The applicant should describe the design and installation criteria applicable to the mounting of pressure-relief devices (i.e., safety and relief valves) for overpressure protection of ASME Class 1, 2, and 3 components and include information to permit evaluation of applicable load combinations and stress criteria. This section should provide information to allow the design review to consider plans for accommodating the rapidly applied reaction force that occurs when a safety or relief valve opens and the transient fluid-induced loads applied to piping downstream from a safety or relief valve in a closed discharge piping system (including dynamic structural response attributable to a BWR safety relief valve discharge into the suppression pool). The applicant should describe the design of safety and relief valve systems with respect to load combinations postulated for the valves, upstream piping or header, downstream or vent piping, system supports, and BWR suppression pool discharge devices such as ramsheads and quenchers, if applicable.

For load combinations, the applicant should identify the most severe combination of applicable loads attributable to internal fluid weight, momentum, and pressure; dead weight of valves and piping; thermal load under heat up; steady-state and transient valve operation; reaction forces when valves are discharging (i.e., thrust, bending, torsion); seismic forces (i.e., SSE); and dynamic forces attributable to BWR safety relief valve discharge in the suppression pool, if applicable. The section should include as valve discharge loads the reaction loads attributable to discharge of loop seal water slugs and subcooled or saturated liquid under transient or accident conditions.

The discussion should include the method of analysis and magnitude of any dynamic load factors used. The applicant should discuss and include in the analysis a description of the structural response of the piping and support system, with particular attention to the dynamic or time history analyses employed in evaluating the appropriate support and restraint stiffness effects under dynamic loadings when valves are discharging. The applicant should present the results of this analysis.

If the applicant proposed to use hydraulic snubbers, it should describe snubber performance characteristics to ensure that their effects have been considered in analyses under steady-state valve operation and repetitive load applications caused by cyclic valve opening and closing during the course of a pressure transient.

C.I.3.9.3.3 ***Pump and Valve Operability Assurance***

The applicant should identify all active ASME Class 1, 2, and 3 pumps and valves. This section should present criteria to be employed in a test program, or a program consisting of tests and analysis, to ensure operability of pumps required to function and valves required to open or close to perform a safety function during or following the specified plant event. The applicant should discuss features of the program, including conditions of test, scale effects (if appropriate), loadings for specified plant event, transient loads (including seismic component, dynamic coupling to other systems, stress limits, deformation limits), and other information pertinent to assurance of operability. The applicant should include the design stress limits established in FSAR Section 3.9.3.1.

The section should also include program results, summarizing stress and deformation levels and environmental qualification, as well as maximum test envelope conditions for which each component qualifies, including end connection loads and operability results.

C.I.3.9.3.4 ***Component Supports***

This section should provide load combinations, system operating transients, stress limits, and deformation limits for component supports, discussed in Section C.I.3.9.3.1 of this guide.

The applicant should furnish information to enable evaluation of supports for ASME Code Class 1, 2, and 3 components, including assessment of design and structural integrity of plate and shell, linear, and component standard types of supports for active components. The applicant should analyze and/or test the component supports as discussed in Section C.I.3.9.3.3 of this guide, and include their effects on operability in the discussion provided in that section. The applicant should present the criteria used for the analysis or test program, as well as the results of the analysis and/or test programs discussed in Sections C.I.3.9.3.1 and C.I.3.9.3.3 of this guide. The combination of loadings considered for each component support within a system, including the designation of the appropriate service stress for each loading combination should be consistent with the criteria in Appendix A, Regulatory Guide 1.124, "Service Limits and Loading Combinations for Class 1 Linear-Type Support" and Regulatory Guide 1.130, "Service Limits and Loading Combinations for Class I Plate-and-Shell-Type Component Supports."

C.I.3.9.4 **<u>Control Rod Drive Systems</u>**

This section should provide information on the control rod drive systems (CRDSs). For electromagnetic systems, the applicant should include the control rod drive mechanism (CRDM) up to the coupling interface with reactivity control elements. For hydraulic systems, the applicant should include the CRDM, hydraulic control unit, condensate supply system, and scram discharge volume, up to the coupling interface with reactivity control elements. For both types of systems, the applicant should treat the CRDM housing as part of the RCPB. FSAR Section 4.5.1 should include information on CRDS materials.

If other types of CRDSs are proposed, or if new features that are not specifically mentioned here are incorporated in current types of CRDSs, the applicant should provide information regarding the new systems or new features.

C.I.3.9.4.1 ***Descriptive Information of CRDS***

The applicant should provide an evaluation of the system's adequacy to properly perform its design function. This evaluation should include design criteria, testing programs, drawings, and a summary of the method of operation of the control rod drives.

C.I.3.9.4.2 ***Applicable CRDS Design Specifications***

The applicant should indicate the design codes, standards, specifications, and standard practices, as well as NRC GDC, regulatory guides, and positions, applied in the design, fabrication, construction, and operation of the CRDS. The list of the various criteria along with the names of the apparatuses to which they apply should include the following:

(1) List of the pressurized parts of the system in FSAR Section 3.2.2.

(a) For those portions that are part of the RCPB, indicate the extent of compliance with the Class 1 requirements in Section III of the ASME Code.

(b) For those portions that are not part of the RCPB, indicate the extent of compliance with other specified parts of Section III or other sections of the ASME Code.

(2) An evaluation of the nonpressurized portions of the CRDS, which demonstrates the acceptability of design margins for allowable values of stress, deformation, and fatigue. If the applicant uses an experimental testing program in lieu of analysis, it should discuss how the program adequately covers stress, deformation, and fatigue in the CRDS. If this experimental testing program is incomplete at the time the COL application is filed, the applicant should describe the implementation program, including milestones, completion dates and expected conclusions.

C.I.3.9.4.3 ***Design Loads, Stress Limits, and Allowable Deformations***

This section should present information that pertains to the applicable design loads and their appropriate combinations, the corresponding design stress limits, and the corresponding allowable deformations. The deformations of interest are those where a failure of movement could occur and such movement is necessary for a safety-related function. The applicant should provide the following information:

(1) If experimental testing is used in lieu of establishing a set of stress and deformation allowable, a description of the testing program, including the load combinations, design stress limits, and allowable deformation criteria. If the experimental testing is incomplete at the time the COL application is filed, a description of the implementation program, including milestones, completion dates and expected conclusions.

(2) For components that are not designed to the ASME Code, the design limits and safety margins.

(3) For components that are designed to the ASME Code, information similar to that requested in Section C.I.3.9.3 of this guide.

(4) Comparison of the actual design with the design criteria and limits to demonstrate that the criteria and limits have not been exceeded.

C.I.3.9.4.4 ***CRDS Operability Assurance Program***

The applicant should provide plans for conducting an operability assurance program or references to previous test programs or standard industry procedures for similar apparatuses. This section should show how the operability assurance program includes a life cycle test program that fulfills the following criteria:

(1) Demonstrate the ability of the control rod drive components to function during and after normal operation, anticipated operational occurrences, seismic events, and postulated accident conditions over the full range of temperatures, pressures, loadings, and misalignment expected in service.

(2) Include functional tests to determine insertion and withdrawal times, latching operation, scram operation and time, system valve operation, and scram accumulator leakage for hydraulic CRDSs, ability to overcome a stuck rod condition, and wear.

The applicant should describe the plan for implementing the operability assurance program, including milestones.

C.I.3.9.5 <u>Reactor Pressure Vessel Internals</u>

The applicant should discuss the specific design codes, load combinations, allowable stress and deformation limits, and other criteria used in designing the reactor internals, for both core support structures designed to the ASME Code and internals designed to other standards. The applicant should ensure the structural and functional integrity of the reactor internals, including the steam dryer.

C.I.3.9.5.1 *Design Arrangements*

The applicant should present the physical or design arrangements of all reactor internals structures, systems, components, and assemblies, including the manner of positioning and securing such items within the reactor pressure vessel, the manner of providing for axial and lateral retention and support of the internals components and assemblies, and the manner of accommodating dimensional changes attributable to thermal and other effects. The description should include the functional requirements for each component. The applicant should verify that any significant changes in design from that used in previously licensed plants of similar design do not affect the acoustic and flow-induced vibration test results requested in Section C.I.3.9.2.4 of this guide.

C.I.3.9.5.2 *Loading Conditions*

This section should specify the plant and system operating conditions and design-basis events that provide the basis for the design of the reactor internals to sustain normal operation, vibratory flow-induced vibration and acoustic loading, anticipated operational occurrences, postulated accidents, and seismic events in accordance with the information requested in Section C.I.3.9.1.1 of this guide.

The applicant should identify the design codes, code cases, and acceptance criteria applicable to the design, analysis, fabrication, and nondestructive examination of the internals components. The discussion should identify internal components that are designated as core support structures and internal structures and discuss the implications of this designation on applicable design criteria. The applicant should also indicate the extent to which the design and construction of the core support structures are in accordance with Subsection NG of the ASME Code and the extent to which the design of other reactor internals will be consistent with Article NG-3000 of the ASME Code. Regulatory Guide 1.20, "Comprehensive Vibration Assessment Program for Reactor Internals During Preoperation and Initial Startup Testing," provides further details on the determination of loading conditions caused by adverse flow effects.

C.I.3.9.5.3 *Design Bases*

The applicant should list all combinations of design and service loadings accounted for in the design of the reactor internals (e.g., acoustic and flow-induced vibration, operating differential pressure and thermal loads, thermal stratification, seismic loads, flow-induced vibration loads, acoustic loads, transient pressure loads associated with postulated LOCAs, and asymmetric blowdown pressurization and loading resulting from pipe ruptures at postulated locations that are not excluded based on LBB analyses). This section should define these loads and describe the method of combining loads for normal, upset, emergency, and faulted service conditions. For each specific load combination, the applicant should provide the allowable design or service limits to be applied to the reactor internals, including steam dryers. Considering the effects of component service environments, the applicant should provide the deflection, cycling, and fatigue limits. The applicant should also verify that the allowable deflections will not interfere with the functioning of all related components (e.g., control rod guide tubes and standby cooling systems). The applicant should provide a summary of the maximum calculated total stress, deformation, and cumulative usage factor for each designated design or service limit. FSAR Section 3.9.2 should present the details of the dynamic analyses.

C.I.3.9.5.4 ***BWR Reactor Pressure Vessel Internals Including Steam Dryer***

The applicant should present a detailed analysis of potential adverse flow effects (flow-induced vibrations and acoustic resonances) that can severely impact reactor pressure vessel internal components (including the steam dryer) and other main steam system components, as applicable. The analysis should be supplemented by Acoustic and computational fluid dynamic analyses and scale model testing should supplement the analysis. The applicant should describe the utilization of instrumentation on vulnerable components (including pressure, strain, and acceleration sensors on the steam dryer), in addition to satisfying the provisions discussed in FSAR Section 3.9.2.4 to obtain direct loading data and to ensure the structural adequacy of those components against the potential adverse flow effects. For a prototype reactor, if the flow-induced vibration testing of reactor internals is incomplete at the time the COL application is filed, the applicant should describe the implementation program, including milestones, completion dates and expected conclusions.

C.I.3.9.6 **<u>Functional Design, Qualification, and Inservice Testing Programs for Pumps, Valves, and Dynamic Restraints</u>**

This section should describe the functional design and qualification provisions and inservice testing (IST) programs for certain safety-related pumps, valves, and dynamic restraints (snubbers) (i.e., those safety-related pumps, valves, and snubbers typically designated as Class 1, 2, or 3 under Section III of the ASME Code, plus those pumps, valves, and snubbers not categorized as Class 1, 2, or 3 but considered to be safety-related) to ensure that they will be in a state of operational readiness to perform their safety functions throughout the life of the plant.

C.I.3.9.6.1 ***Functional Design and Qualification of Pumps, Valves, and Dynamic Restraints***

In this section, the applicant should do the following:

(1) describe the provisions in the design of safety-related pumps, valves, and piping that allow testing of pumps and valves at the maximum flow rates specified in the plant accident analyses

(2) describe the provisions in the functional design and qualification of each safety-related pump and valve that demonstrate the capacity of the pumps and valves to perform their intended functions for a full range of system differential pressures and flows, ambient temperatures, and available voltage (as applicable) from normal operating to design-basis conditions

(3) verify that the qualification program for safety-related valves that are part of the RCPB includes testing and analyses to demonstrate that these valves will not experience any leakage, or increase in leakage, from their loading

(4) describe the provisions in the functional design and qualification of dynamic restraints in safety-related systems and access for performing IST program activities that comply with the requirements in the latest edition and addenda of the OM code incorporated by reference in 10 CFR 50.55a on the date 12 months before the date for initial fuel load

(5) give particular attention to flow-induced loading in functional design and qualification to incorporate degraded flow conditions such as those that might result from the presence of debris, impurities, and contaminants in the fluid system (e.g., containment sump pump recirculating water with debris)

C.I.3.9.6.2 ***Inservice Testing Program for Pumps***

The applicant should provide the following:

(1) a list of pumps to be included in the IST program, including their code class

(2) description of the IST program (including test parameters and acceptance criteria) for pump speed, fluid pressure, flow rate, and vibration at normal, IST, and design-basis operating conditions

(3) description of the proposed methods for establishing and measuring the reference values and IST values for the pump parameters listed above, including instrumentation accuracy and range

(4) the proposed pump test plan and schedule (including test duration)

(5) description of the implementation program, including milestones, for the pump IST programs that comply with the requirements in the latest edition and addenda of the OM code incorporated by reference in 10 CFR 50.55a on the date 12 months before the date for initial fuel load.

C.I.3.9.6.3 ***Inservice Testing Program for Valves***

The applicant should provide the following:

(1) a list of valves to be included in the IST program, including their type, valve identification number, code class, procedures, valve category, valve functions, test parameters and test frequency

(2) proposed methods for measuring the reference values and IST values for power-operated valves (POVs), including motor-operated valves (MOVs), air-operated valves, hydraulic-operated valves, and solenoid-operated valves

(3) valve test procedures and schedules (including justifications for cold shutdown and refueling outage test schedules)

(4) description of the implementation program, including milestones, for the valve IST programs that comply with the requirements in the latest edition and addenda of the OM code incorporated by reference in 10 CFR 50.55a on the date 12 months before the date for initial fuel load (including specific milestones associated with the implementation of MOV programs)

C.I.3.9.6.3.1 **<u>Inservice Testing Program for Motor-Operated Valves</u>**

In this section, the applicant should do the following:

(1) Describe the IST program that will periodically verify the design-basis capability of safety-related MOVs.

  (a) Show how periodic testing (or analysis combined with test results where testing is not conducted at design-basis conditions) will objectively demonstrate continued MOV capability to open and/or close under design-basis conditions.

  (b) Justify any IST intervals that exceed either 5 years or 3 refueling outages (whichever is longer).

(2) Show how successful completion of the preservice and inservice testing of MOVs will demonstrate that the valves meet the following criteria:

  (a) Valve fully opens and/or closes as required by its safety function.

(b) Adequate margin exists and includes consideration of diagnostic equipment inaccuracies, degraded voltage, control switch repeatability, load-sensitive MOV behavior, and margin for degradation.

(c) Maximum torque and/or thrust (as applicable) achieved by the MOV (allowing sufficient margin for diagnostic equipment inaccuracies and control switch repeatability) does not exceed the allowable structural and undervoltage motor capability limits for the individual parts of the MOV.

C.I.3.9.6.3.2 Inservice Testing Program for Power-Operated Valves Other Than MOVs

In this section, the applicant should do the following:

(1) Describe how the POVs will be qualified to perform their design-basis functions either before installation or as part of preoperational testing.

(2) Describe the POV IST program and show how the program incorporates the lessons learned from MOV analysis and tests performed in response to Generic Letter 89-10, "Safety-Related Motor-Operated Valve Testing and Surveillance," dated June 28, 1989.

(3) Explain how solenoid-operated valves are verified to meet their Class 1E electrical requirements by performing their safety functions for the appropriate electrical power supply amperage and voltage.

C.I.3.9.6.3.3 Inservice Testing Program for Check Valves

In this section, the applicant should do the following:

(1) Describe the preservice and inservice tests to be conducted on each check valve

(a) Describe the diagnostic equipment or nonintrusive techniques that will be used to monitor internal component condition and measure such parameters as fluid flow, disk position, disk movement, disk impact forces, leak tightness, leak rates, degradation, and disk testing. Describe the diagnostic equipment and its operating principles and justify the technique. Discuss how the operation and accuracy of the diagnostic equipment and techniques will be verified during preservice testing.

(b) Verify that testing will take place (to the extent practical) under the temperature and flow conditions that will exist during normal operation, as well as cold shutdown, and in other modes if such conditions are significant.

(c) Verify that the testing results will identify the flow required to open the valve to the full-open position.

(d) Verify that testing will include the effects of rapid pump starts and stops and any other reverse flow conditions that expected system operating conditions may require.

(2) Explain the nonintrusive (diagnostic) techniques to be used to periodically assess degradation and performance characteristics of check valves.

(3) Verify that the acceptance criteria for successful completion of the preservice and inservice testing will include the following assessments:

(a) Demonstrate that the valve disk fully opens or fully closes as expected during all test modes that simulate expected system operating conditions based on the direction of the differential pressure across the valve.

(b) Determine valve disk positions without disassembly.

(c) Verify free disk movement to and from the seat.

(d) Demonstrate that the valve disk is stable in the open position under normal and other required system operating fluid flow conditions.

(e) For passive plant designs, verify that the valve disk moves freely off the seat under normal and other minimum expected differential pressure conditions.

(4) Confirm that piping design features will accommodate all applicable check valve testing requirements.

(5) Show how the valve IST program meets the requirements of Appendix II to the ASME Operation and Maintenance (OM) Code.

C.I.3.9.6.3.4 Pressure Isolation Valve Leak Testing

The applicant should list the pressure isolation valves, including the classification, allowable leak rate, and test interval for each valve.

C.I.3.9.6.3.5 Containment Isolation Valve Leak Testing

The applicant should provide a list of containment isolation valves, including the allowable leak rate for each valve or valve combination.

C.I.3.9.6.3.6 Inservice Testing Program for Safety and Relief Valves

The applicant should provide a list of valves that are to be included in the IST program, including their type, code class, valve category, valve functions, test parameters, and test frequency.

C.I.3.9.6.3.7 Inservice Testing Program for Manually Operated Valves

The applicant should list the manually operated valves, including their safety-related function.

C.I.3.9.6.3.8 Inservice Testing Program for Explosively Activated Valves

The applicant should list explosively actuated valves, including a test plan and corrective actions.

C.I.3.9.6.4 *Inservice Testing Program for Dynamic Restraints*

To describe the IST program for dynamic restraints, the applicant should do the following:

(1) Provide a table listing all safety-related components that use snubbers in their support systems:

(a) Identify the systems and components that use snubbers.

(b) Indicate the number of snubbers used in each system and on the components in that system.

(c) Identify the type(s) of snubber (hydraulic or mechanical).

(d) Specify the standards to which the snubbers comply.

(e) State whether the snubber is used as a shock, vibration, or dual-purpose snubber.

(f) If a snubber is identified as either a dual-purpose or vibration arrester type, indicate whether the snubber and/or component were evaluated for fatigue strength.

(2) Describe the IST program (including test frequency and duration and examination methods) related to visual inspections (e.g., checking for degradation, cracked fluid reservoirs, missing parts, and leakage) and functional testing of dynamic restraints. Describe and state the basis for dynamic restraint testing.

(3) Describe the steps to be taken to ensure that all snubbers are properly installed before preoperational piping and plant startup tests.

(4) Confirm the accessibility provisions for maintenance, inservice inspection and testing, and possible repair or replacement of snubbers.

(5) Describe the implementation program, including milestones, for the snubber IST programs that comply with the requirements in the latest edition and addenda of the OM code incorporated by reference in 10 CFR 50.55a on the date 12 months before the date for initial fuel load.

C.I.3.9.6.5 ***Relief Requests and Alternative Authorizations to ASME OM Code***

The applicant should provide information regarding components for which the applicant is requesting relief from (or proposing an alternative to) the ASME OM Code requirements. The information should include the following:

(1) Identification of the component by name, number, functions, class under Section III of the ASME Code, valve category (as defined in ISTC-1033 of the ASME OM Code), and pump group (as defined in ISTB-2000 of the ASME OM Code).

(2) Identification of the ASME OM Code requirement(s) from which the applicant is requesting relief or to which the applicants is requesting an alternative.

(3) For a relief request pursuant to 10 CFR 50.55a(f)(6)(I) or (g)(6)(I), the basis for requesting the relief and an explanation of why compliance with the ASME OM Code is impractical or should otherwise not be required.

(4) For an alternative request pursuant to 10 CFR 50.55a(a)(3), details regarding the proposed alternative(s) demonstrating that (1) the proposed IST will provide an acceptable level of quality and safety, or (2) compliance with the specified requirement would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

(5) Description of the plan, including milestones, for implementing the proposed IST program.

C.I.3.9.7 **[Reserved]**

C.I.3.9.8 **[Reserved]**

C.I.3.10 ***Seismic and Dynamic Qualification of Mechanical and Electrical Equipment***

The applicant should identify all instrumentation, electrical equipment, and mechanical components (other than pipes), including their supports, that should be designed to withstand the effects of earthquakes and the full range of normal and accident loadings. This equipment should include (1) equipment associated with systems that are essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment reactor heat removal; (2) equipment essential to preventing significant release of radioactive material to the environment, and (3) instrumentation needed to assess plant and environs conditions during and after an accident as described in Regulatory Guide 1.97, “Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants.” The applicant should identify equipment (1) that performs the above functions automatically, (2) that operators use to perform the above functions manually, and (3) for which failure can prevent satisfactory accomplishment of one or more of the above safety functions. This includes equipment in the reactor protection system, engineered safety features Class 1E equipment, the emergency power system, and all auxiliary safety-related systems and supports. Examples of mechanical equipment include pumps, valves, fans, valve operators, snubbers, battery and instrument racks, control consoles, cabinets, and panels; examples of electrical equipment include valve operator motors, solenoid valves, relays, pressure switches, level transmitters, electrical penetrations, and pump and fan motors.

C.I.3.10.1 Seismic Qualification Criteria

The applicant should provide the criteria used for seismic qualification, including the decision criteria for selecting a particular test or method of analysis, the considerations defining the seismic and other relevant dynamic load input motion, and the process to demonstrate the adequacy of the seismic qualification program. The applicant should indicate the extent to which the seismic qualification criteria use the guidance in Regulatory Guide 1.100, “Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants” and provide suitable justifications for any exceptions to this guidance.

C.I.3.10.2 Methods and Procedures for Qualifying Mechanical and Electrical Equipment and Instrumentation

This section should describe the methods and procedures, including test and/or analysis results, used to ensure the structural integrity and functionality of mechanical and electrical equipment for operation in the event of an SSE. If the applicant is required to postulate an OBE, the applicant should address five occurrences of the OBE followed by a full SSE event or a number of fractional peak cycles equivalent to the maximum peak cycle for five OBE events followed by one full SSE, in combination with other relevant design-basis loads.

C.I.3.10.3 Methods and Procedures of Analysis or Testing of Supports of Mechanical and Electrical Equipment and Instrumentation

In this section, the applicant should describe the methods and procedures, including results, used to analyze or test the supports for mechanical and electrical equipment, as well as the verification procedures used to account for possible amplification of vibratory motion (amplitude and frequency content) under seismic and dynamic conditions. The description should include supports for such items as battery racks and instrument racks, pumps, valves, valve operators, fans, control consoles, cabinets, panels, and cable trays.

C.I.3.10.4 Test and Analyses Results and Experience Database

The applicant should provide the results of tests and analyses that demonstrate adequate seismic qualification. If the seismic and dynamic qualification testing is incomplete at the time of the COL application, the applicant should include an implementation program, including implementation program, including milestones and completion dates with appropriate information submitted for staff review and approval prior to installation and equipment. If qualification by experience is proposed, the applicant should submit for staff review and approval the methods and procedures, including details of the experience database, to ensure the structural integrity and functionality of the in-scope mechanical and electrical equipment as described in Section C.I.3.10.2 of this guide.

C.I.3.11 *Environmental Qualification of Mechanical and Electrical Equipment*

The applicant should identify the electrical equipment (including instrumentation and control and certain accident monitoring equipment specified in Regulatory Guide 1.97) that is within the scope of 10 CFR 50.49, "Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants." This equipment must perform its safety functions under all normal environmental conditions, anticipated operational occurrences, and accident and postaccident environmental conditions. Include the mechanical and electrical equipment associated with systems essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal. The applicant should also include equipment for which postulated failure might affect the safety function of safety-related equipment or mislead an operator, as well as equipment that is otherwise essential to prevent significant releases of radioactive material to the environment.

C.I.3.11.1 Equipment Location and Environmental Conditions

This section should specify the location of each piece of equipment, both inside and outside containment. For equipment inside containment, the applicant should specify whether the location is inside or outside of the missile shield (for pressurized water reactors), or inside or outside of the drywell (for BWRs)., as applicable or specify the equipment locations in accordance with harsh environment zones.

The applicant should specify both the normal and accident environmental conditions for each item of equipment, including temperature, pressure, humidity, radiation, chemicals, submergence, and vibration (nonseismic) at the location where the equipment must perform. For the normal environment, the applicant should provide specific values, including those attributable to loss of environmental control systems. For the accident environment, the applicant should identify the cause of the postulated environment (e.g., LOCA, steam line break, or other), specify the environmental conditions as a function of time, and identify the length of time that each item of equipment is required to operate in the accident environment.

C.I.3.11.2 Qualification Tests and Analyses

The applicant should demonstrate that (1) the equipment is capable of maintaining functional operability under all service conditions postulated to occur during the equipment's installed life for the time it is required to operate, and (2) failure of the equipment after performance of its safety function will not be detrimental to plant safety or mislead an operator. The applicant should consider all environmental conditions that may result from any normal mode of plant operation, anticipated operational occurrences, design-basis events, post-design-basis events, and containment tests. The applicant should describe the qualification tests and analyses performed on each item of equipment to ensure that it will perform under the specified normal and accident environmental conditions.

In this section, the applicant should document how the design will meet the requirements of 10 CFR 50.49; GDC 1, 2, 4, and 23 of Appendix A to 10 CFR Part 50; and Criteria III, XI, and XVII of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50. The applicant should indicate the extent to which it will use the guidance contained in applicable regulatory guides (some of which are listed below), or document and justify the use of alternative approaches:

- Regulatory Guide 1.40, “Qualification Tests of Continuous-Duty Motors Installed Inside the Containment of Water-Cooled Nuclear Power Plants”
- Regulatory Guide 1.63, “Electric Penetration Assemblies in Containment Structures for Light-Water-Cooled Nuclear Power Plants”
- Regulatory Guide 1.73, “Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants”
- Regulatory Guide 1.89, “Environmental Qualification of Certain Electrical Equipment Important to Safety for Nuclear Power Plants”
- Regulatory Guide 1.97, “Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident”
- Draft Regulatory Guide 1.131, “Qualification Tests of Electric Cables, Field Splices, and Connections for Light-Water-Cooled Nuclear Power Plants”
- Regulatory Guide 1.156, “Environmental Qualification of Connection Assemblies for Nuclear Power Plants”
- Regulatory Guide 1.158, “Qualification of Safety-Related Lead Storage Batteries for Nuclear Power Plants”
- Regulatory Guide 1.180, “Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems”
- Regulatory Guide 1.183, “Alternative Radiological Source Terms for Evaluating Design-Basis Accidents at Nuclear Power Reactors”

C.I.3.11.3 <u>Qualification Test Results</u>

The applicant should document the qualification test results and qualification status for each type of equipment. Because the Environmental Qualification program is an operational program, as discussed in SECY-05-0197, the program and its implementation milestones should be fully described and reference any applicable standards. Fully described should be understood to mean that the program is clearly and sufficiently described in terms of the scope and level of detail to allow for a reasonable assurance finding of acceptability. This statement applies to all of Subsection C.I.3.11.

C.I.3.11.4 <u>Loss of Ventilation</u>

The applicant should describe the bases that ensure that loss of environmental control systems (e.g., heat tracing, ventilation, heating, air conditioning) will not adversely affect the operability of each item of equipment, including electric control and instrumentation equipment and instrument sensing lines that rely on heat tracing for freeze protection. The description should include the analyses performed to identify the “worst case” environment (e.g., temperature, humidity), including identification and determination of the limiting condition with regard to temperature that would require reactor shutdown. The applicant should describe any testing (factory or on site) performed to confirm satisfactory operability of control and electrical equipment under extreme environmental conditions and document the successful completion of qualification tests and qualification status for each type of equipment.

C.I.3.11.5 <u>Estimated Chemical and Radiation Environment</u>

The applicant should identify the chemical environment for both normal operation and the design-basis accident. For engineered safety features inside containment (e.g., containment spray, emergency core cooling system initiation, or recirculating phase), the applicant should identify the chemical composition and resulting pH of the liquids in the reactor core and the containment sump.

The applicant should identify the radiation dose and dose rate used to determine the radiation environment and indicate the extent to which estimates of radiation exposures are based on a radiation source term that is consistent with NRC staff-approved source terms and methodology. For exposure of organic components on engineered safety feature systems, the applicant should tabulate beta and gamma exposures separately for each item of equipment and list the average energy of each type of radiation. For engineered safety feature systems outside containment, the applicant should indicate whether the radiation estimates account for factors affecting the source term such as containment leak rate, meteorological dispersion (if appropriate), and operation of other engineered safety feature systems. The applicant should list all assumptions used in the calculation.

This section should document successful completion of qualification tests and qualification status for each type of equipment.

C.I.3.11.6 Qualification of Mechanical Equipment

The applicant should define the process for determining the suitability of environmentally sensitive mechanical equipment (e.g., seals, gaskets, lubricants, fluids for hydraulic systems, and diaphragms) needed for safety-related functions and for verifying that the design of such materials, parts, and equipment is adequate. The applicant should identify the following:

(1) safety-related mechanical equipment located in harsh environmental areas

(2) nonmetallic subcomponents of such equipment

(3) the environmental conditions and process parameters for which this equipment must be qualified

(4) the nonmetallic material capabilities

(5) the environmental effects on the nonmetallic components of the equipment

The applicant should document successful completion of qualification tests and/or analysis and qualification status for each type of equipment.

C.I.3.12 *Piping Design Review*

C.I.3.12.1 Introduction

This section covers the design of the piping system and piping support for seismic Category I, Category II, and nonsafety systems. It also discusses the adequacy of the structural integrity, as well as the functional capability, of the safety-related piping system, piping components, and their associated supports. The design of piping systems should ensure that they perform their safety-related functions under all postulated combinations of normal operating conditions, system operating transients, postulated pipe breaks, and seismic events. This includes pressure-retaining piping components and their supports, buried piping, instrumentation lines, and the interaction of non-seismic Category I piping and associated supports with seismic Category I piping and associated supports. This section covers the design transients and resulting loads and load combinations with appropriate specified design and service limits for seismic Category I piping and piping support, including those designated as ASME Code Class 1, 2, 3, and those not covered by the ASME Code.

C.I.3.12.2 Codes and Standards

The applicant should provide a table showing compliance with the NRC's regulations in 10 CFR 50.55a. This table should identify the piping system and associated supports.

The applicant should discuss the design and analyses of the piping system, including piping components and associated supports in accordance with Section III of the ASME Code. The discussion should cover requirements and procedures used in preparing the design specification of the piping system, including loading combinations, design data, and other design inputs. It should also identify design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards used in the design or that will be used in the fabrication, construction, testing, and inservice inspection of the piping system. The applicant should identify the specific edition, date, or addenda of each document.

The ASME Code cases that may be used for the design of the ASME Code Class l, 2,and 3 piping system are those recommended in Regulatory Guide 1.84, "Design, Fabrication, and Materials Code Case Acceptability, ASME Section III." The design reports for ASME Code Class 1, 2, and 3 piping system and piping support should be available for NRC audit.

C.I.3.12.3 Piping Analysis Methods

The applicant should identify and describe the design consistent with seismic subsystem analysis related to seismic analysis methods (e.g., response spectrum analysis, modal time history analysis, direct integration time history analysis, frequency domain time history analysis, equivalent static load analysis) used for seismic Category I and non-seismic Category I (seismic Category II and nonseismic) piping system and piping support.

The applicant should explain the manner in which the seismic dynamic analysis considers maximum relative displacement among supports and indicate other significant effects accounted for in the analysis, such as hydrodynamic effects and nonlinear response.

This section should describe the procedure used for analytical modeling, number of earthquake cycles, selection of frequencies, damping criteria (consistent with Regulatory Guide 1.61, "Damping Values for Seismic Design of Nuclear Power Plants"), combination of modal responses, equivalent static factors, the analysis for small bore piping, and interaction of Category I systems with other systems. Since there are numerous technical issues related to piping design and piping support other than seismic and those criteria discussed in the SRP, the applicant should also discuss any acceptable methods that are common industry practices and/or practical engineering considerations proven through extensive experience.

C.I.3.12.3.1 *Experimental Stress Analyses*

If the applicant uses experimental stress analysis methods in lieu of analytical methods for seismic Category I ASME Code and non-ASME Code piping system design, it should provide sufficient information to show the validity of the design. It is recommended that, before using the experimental stress analysis method, the applicant submit the details of the method, as well as the scope and extent of its application, for approval. The experimental stress analysis method should comply with Appendix II to ASME Code, Section III, Division 1.

C.I.3.12.3.2 ***Modal Response Spectrum Method***

Modal response spectrum and time history methods form the basis for the analyses of all major seismic Category I piping systems and components. The applicant should describe the procedures for considering the three components of earthquake motion in determining seismic response of piping system and piping support and the procedure for combining modal responses (i.e., shears, moments, stresses, deflections, and accelerations), including that for modes with closely spaced frequencies. Also, the applicant should indicate the extent to which it has followed the recommendations of Regulatory Guide 1.92, including those applicable to adequate consideration of high-frequency modes, to combine modal responses.

If the applicant uses any alternative seismic analysis method, it should provide the basis for its conservatism and equivalence in safety to the applicable regulatory position.

C.I.3.12.3.3 ***Response Spectra Method (or Independent Support Motion Method)***

As an alternative to the enveloped response spectra method, the applicant may use independent support motion seismic analyses where there is more than one supporting structure for the piping system. This means that all supports are located on the same floor or portions of the floor of a structure. A support group is defined by supports that have the same time history input. The analysis combines the responses from motions of supports in two or more different groups by the square root sum of the squares method. For this procedure, the criteria for damping values should be consistent with those in Regulatory Guide 1.61.

C.I.3.12.3.4 ***Time History Method***

The applicant may perform a time history analysis using either the modal superposition method or the direct integration method. The applicant should include the following in its description of the seismic analysis method used:

(1) manner in which the dynamic system analysis is performed

(2) method chosen for selection of significant modes and an adequate number of masses or degrees of freedom

(3) manner in which the seismic dynamic analysis considers maximum relative displacements between supports

(4) other significant effects accounted for in the dynamic seismic analysis, such as piping interactions, externally applied structural restraints, hydrodynamic effects (both mass and stiffness effects), types of loading and condition, damping criteria, and nonlinear response

If the applicant uses a static load method instead of a dynamic analysis, it should demonstrate that a simple model can realistically represent the system l and that the method produces conservative results.

C.I.3.12.3.5 ***Inelastic Analyses Method***

The applicant should describe in detail the methodology, the specific system, and the acceptance criteria if it uses the inelastic analyses method for piping design analyses. The acceptance criteria used should be consistent with those contained in SRP Section 3.9.1. Before using the inelastic method for analyses, the applicant should submit it for review and approval.

C.I.3.12.3.6 ***Small-Bore Piping Method***

The response spectrum method is an acceptable seismic analysis methodology for evaluating both small- and large-bore piping. The applicant should describe in detail the method used for seismic analysis, including analyses procedure and criteria for small- and large-bore piping. If the applicant proposes an equivalent static load method, the method should be consistent with the recommendations of SRP Section 3.9.2.II.2.a(2)(c). The applicant should explain the basis for the method's conservatism and equivalence in safety to the applicable regulatory position.

C.I.3.12.3.7 ***Nonseismic/Seismic Interaction (II/I)***

The applicant should describe the location of all piping systems (seismic Category I, seismic Category II, and nonseismic structures), including the distance between various piping systems. The applicant should provide the design criteria used to account for seismic motion of non-seismic Category I (seismic Category II and nonseismic) piping or portions thereof in the seismic design of seismic Category I structures or portions thereof. The description should include the seismic design of non-seismic Category I piping systems whose continued function is not required, but whose failure could adversely impact the safety function of SSCs. The applicant should describe the design criteria that it will apply to ensure functionality of seismic Category I systems despite impacts from the failure of non-seismic Category I piping because of seismic effects.

C.I.3.12.3.8 ***Seismic Category I Buried Piping***

The applicant should describe seismic criteria and methods for considering the effects of earthquakes on buried piping, conduits, tunnels, and auxiliary systems. These criteria should include compliance characteristics of soil media; dynamic pressures; seismic wave passage; and settlement resulting from earthquake and differential movements at support points, penetrations, and entry points into other structures provided with anchors.

C.I.3.12.4 **<u>Piping Modeling Technique</u>**

The applicant should provide criteria and procedures used for modeling that are applicable to seismic Category I ASME Code and non-ASME Code piping systems. The applicant should include criteria and bases used to determine whether the piping system and piping support are being analyzed as part of a system analysis or independently as a subsystem. The applicant should describe the types of model (finite element model, lumped-mass stick model, hybrid model, etc.) used for the seismic Category I piping system. Using methods recommended in SRP Section 3.9.1, the applicant should describe and provide verification of all computer programs used for analyses of seismic Category I piping designated as ASME Code Class 1, 2, and 3 and non-ASME Code items. The applicant should describe the computer codes used for the design of the piping systems and supports and verify that these computer codes are in accordance with those used in the NRC benchmark problems appropriate for these piping analyses methods. The SRP provides references to the NRC benchmark problems.

C.I.3.12.4.1 ***Computer Codes***

The applicant should provide a list of computer programs used in dynamic and static analyses to determine the structural and functional integrity of seismic Category I ASME Code and non-ASME Code piping systems, consistent with Section C.I.3.9.1.2 of this guide.

C.I.3.12.4.2 ***Dynamic Piping Model***

The applicant should describe the types of model (finite element, hybrid model, etc.) used for seismic Category I piping and piping support and provide the criteria and procedures used for modeling in the seismic system analyses. The applicant should indicate how the dynamic piping model for the seismic system analyses accounts for the effects of torsion (including eccentric masses), bending, shear, and axial deformations, and effects resulting from the changes in stiffness values of curved members. The applicant should also include the criteria and bases used to determine whether a piping system is analyzed as part of a larger structural system analysis or independently as a subsystem.

C.I.3.12.4.3 ***Piping Benchmark Program***

The applicant should provide a list of computer programs used in dynamic and static analyses to determine the structural and functional integrity of the seismic Category I piping system design and the non-ASME Code piping system design. The applicant should also verify that the computer programs used for the analysis are in accordance with the appropriate NRC benchmark problems for the analyses methods used for design. The SRP provides references to the NRC benchmark problems.

The applicant should provide the mathematical models for a series of selected piping systems and the associated analyses using the computer programs identified above. This section should compare the results of the analyses of each model to modal frequencies, maximum pipe moments, maximum support loads, maximum equipment nozzle loads, and maximum deflections. For values obtained using the computer program, the applicant should justify any deviations from values obtained using the approved dynamic analyses method.

C.I.3.12.4.4 ***Decoupling Criteria***

The applicant should provide the criteria used to decouple smaller piping systems from larger piping systems. When piping is supported by larger piping, the applicant should use either a coupled dynamic model of the supported piping and supporting piping or the amplified response spectra at the connection point to the supporting piping, with a decoupled model of the supported piping.

C.I.3.12.5 **Piping Stress Analysis Criteria**

C.I.3.12.5.1 ***Seismic Input Envelope vs. Site-Specific Spectra***

The applicant should provide design ground motion response spectra for the SSE. If the ground response spectra differ from the generic ground response spectra, such as the response criteria provided in Regulatory Guide 1.60, the applicant should provide the procedure to calculate response spectra and its basis for each damping ratio used.

The applicant should describe the procedures, basis, and justification for developing floor response spectra as specified in Regulatory Guide 1.122, "Development of Floor Design Response Spectra.." If the applicant uses a single artificial time history analysis method to develop floor response spectra, it should demonstrate that (1) provisions of Regulatory Guide 1.122, including peak broadening requirements, apply, and (2) the response spectra of the artificial time history to be employed in the free field envelops the free-field design response spectra for all damping values actually used in the response spectra. If the applicant applies multiple time histories to generate floor response spectra, it should provide the basis for the methods used to account for uncertainties in parameters.

C.I.3.12.5.2 ***Design Transients***

The applicant should provide a complete list of transients used in the design and fatigue analysis of all ASME Code Class 1 piping system and support components consistent with Section C.I.3.9.1.1 of this guide.

C.I.3.12.5.3 ***Loadings and Load Combination***

This section should provide the design and service loading combinations for piping system and pipe support, consistent with Section C.I.3.9.3.1 of this guide.

C.I.3.12.5.4 ***Damping Values***

The applicant should provide the specific percentage of critical damping values used for seismic Category I piping system and piping support (e.g., damping values for the type of construction or fabrication). Also, the applicant should compare the damping values assigned to the piping system and piping support with the acceptable damping values provided in Regulatory Guide 1.61. The applicant should explain the basis for any proposed damping values that differ from those recommended in Regulatory Guide 1.61 and the rationale for the proposed variation.

C.I.3.12.5.5 ***Combination of Modal Responses***

When using the response spectrum analysis method to evaluate seismic response of piping system and piping support, the applicant should describe the procedure for combining modal responses (i.e., shears, moments, stresses, deflections, and accelerations), including that for modes with closely spaced frequencies. Also, the applicant should indicate the extent to which it is following the recommendations for combining modal responses given in Regulatory Guide 1.92, including those applicable to adequate consideration of high-frequency modes.

C.I.3.12.5.6 ***High-Frequency Modes***

The applicant should describe the method used to account for selection of high-frequency modes in seismic response spectrum analysis of the piping system and piping support. The method proposed should be consistent with the recommendation in Appendix A to SRP Section 3.7.2. If the applicant proposes an alternative in lieu of these methods, it should provide the basis for the alternative's conservatism and equivalence in safety to the applicable regulatory position.

C.I.3.12.5.7 ***Fatigue Evaluation of ASME Code Class 1 Piping***

The applicant should describe the method used to account for effects of the environment on the fatigue design of the piping system.

C.I.3.12.5.8 ***Fatigue Evaluation of ASME Code Class 2 and 3 Piping***

This section should describe the method used to account for effects of the environment on the fatigue design of the Class 2 and 3 piping system and associated support.

C.I.3.12.5.9 ***Thermal Oscillations in Piping Connected to the Reactor Coolant System***

The applicant should describe the piping stress analyses methodology developed for the design of the piping system connected to the reactor coolant system for identification and evaluation of piping systems susceptible to thermal stresses from unanalyzed temperature oscillation. The applicant should describe a program to ensure continued integrity of the piping system consistent with NRC Bulletin Letter 88-08, "Thermal Stresses in Piping Connected to Reactor Coolant Systems," issued in June 1988. If the applicant proposes an alternative in lieu of these methods to ensure the integrity of the piping system, it should provide the basis for the alternative's conservatism and equivalence in safety to the applicable regulatory position.

C.I.3.12.5.10 ***Thermal Stratification***

The applicant should evaluate and describe the method for the piping design to compensate for the effects of thermal stratification and cycling identified in Bulletin Letters 79-13, "Cracking in Feedwater System Piping," issued in August 1979, and 88-11, "Pressurizer Surge Line Thermal Stratification," issued in December 1988, of thermal stratification and cycling. The applicant should describe a program that will ensure continued integrity of the piping system to compensate for thermal stratification as describe in the bulletin letters. If the applicant proposes any other method in lieu of these methods, it should provide the basis for the method's conservatism and equivalence in safety to the applicable regulatory position.

C.I.3.12.5.11 ***Safety Relief Valve Design, Installation, and Testing***

The applicant should describe the design and installation criteria applicable to the piping system and piping support when connected to pressure-relief devices (i.e., safety and relief valves) for overpressure protection of ASME Class 1, 2, and 3 components meeting the criteria specified in Section C.I.3.9.3.2 of this guide.

C.I.3.12.5.12 ***Functional Capability***

The applicant should identify and describe the design of all ASME Code Class 1, 2, and 3 piping systems whose functionality is essential for safe shutdown for all Service Level D loading conditions. The design should be consistent with recommendations in NUREG-1367, "Functional Capability of Piping Systems," and GDC 2.

C.I.3.12.5.13 ***Combination of Inertial and Seismic Anchor Motion Effects***

If piping is supported at multiple locations within a single structure or is attached to two separate structures, the applicant should describe the methods and analyses of the piping system relative to building movements at supports and anchors (seismic anchor motion), as well as with respect to the effects of seismic inertial loads. The applicant should also evaluate the effects of relative displacements at support points by imposing the maximum support displacements in the most unfavorable combination consistent with SRP Section 3.9.2.

C.I.3.12.5.14 ***Operating-Basis Earthquake as a Design Load***

Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants," to 10 CFR Part 50 allows the use of single-earthquake design by providing the option to use an OBE value of one-third the maximum vibratory ground acceleration of the SSE and to eliminate the requirement to perform explicit response analyses for the OBE.

For applications that use this option, the applicant should provide an evaluation to determine the effects of displacement-limited seismic anchor motions on ASME Code components and supports to ensure their functionality during and following an SSE. For piping systems, the evaluation should combine the effects of seismic anchor motions from an SSE with the effects of other normal operational loadings that might occur concurrently. NUREG-1503, "Final SER Related to Certification of the Advanced BWR Design," issued in 1994, states the conditions for these criteria.

C.I.3.12.5.15 ***Welded Attachments***

The applicant should describe and explain the design of support members, connections, or attachments welded to piping. These should be designed such that their failure under unanticipated loads does not cause failure in the pipe pressure boundary. Any code cases used as the basis for design of welded attachments should be consistent with those in Regulatory Guide 1.84.

C.I.3.12.5.16 ***Modal Damping for Composite Structures***

The applicant should describe the procedure used to determine the composite modal damping value for the piping system. Composite modal damping for coupled building and piping systems may be used for piping systems that are coupled to concrete building structures.

Composite modal damping may also be used for piping systems coupled to flexible equipment or flexible valves. The composite modal damping approach should be consistent with the acceptance criteria given in SRP Section 3.7.2.

C.I.3.12.5.17 ***Minimum Temperature for Thermal Analyses***

This section should provide the thermal expansion analyses criteria for the piping design to evaluate the stresses and loadings above the stress-free reference temperature.

C.I.3.12.5.18 ***Intersystem Loss-of-Coolant Accident***

This section should describe and evaluate the various design features of the low-pressure piping systems that interface with the RCPB. The design of the low-pressure piping systems should be such that it can withstand full reactor coolant system pressure without compromising its functionality.

C.I.3.12.5.19 ***Effects of Environment on Fatigue Design***

The applicant should describe the method and procedures used to account for the effects of the environment on the fatigue design of piping system and associated support connected to RCPB components. The method proposed should be consistent with the recommendations of the Regulatory Guide 1.76, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants."

C.I.3.12.6 **<u>Piping Support Design Criteria</u>**

This section should describe the method used in the design of ASME Code Class 1, 2, and 3 pipe supports.

C.I.3.12.6.1 ***Applicable Codes***

The applicant should provide design codes, standards, specifications, regulations, GDC, regulatory guides, and other industry standards that are used in the design or that will be used in the fabrication, construction, testing, and inservice inspection of the piping support. The application should identify the specific edition, date, or addenda of each document. The design of piping supports should be in accordance with ASME Code, Section III, Class 1, 2, and 3, Subsection NF and Appendix F, and AISC N690 (1994) including Supplement 2 (2004).

C.I.3.12.6.2 ***Jurisdictional Boundaries***

This section should describe the jurisdictional boundaries between pipe supports and interface attachment points. The jurisdictional boundaries should be in accordance with Subsection NF of Section III of the ASME Code and AISC N690 (1994) including Supplement 2 (2004).

C.I.3.12.6.3 ***Loads and Load Combinations***

The applicant should provide loads, loading combinations (including system operating transients), and stress criteria for piping supports, including margins of safety. The stress limits for pipe support designs should meet the criteria of ASME Code Section III, Subsection NF.

C.I.3.12.6.4 ***Pipe Support Baseplate and Anchor Bolt Design***

The applicant should describe the design of pipe support baseplate and anchor bolts. The design of the pipe support baseplate and anchor bolts should be consistent with NRC Bulletin Letter 79-02, Revision 2, "Pipe Support Base Plate Designs Using Concrete Expansion Anchor Bolts," issued In March 1979. If the applicant uses any other design, it should provide the basis for the design's conservatism and equivalence in safety to the applicable regulatory position.

C.I.3.12.6.5 ***Use of Energy Absorbers and Limit Stops***

The applicant should provide the design and analyses of the special engineered supports (rigid gapped supports) used in the piping system. The recommended analyses consist of an iterative response spectra analysis of the piping and support system. The iterations establish calculated piping displacements that are compatible with the stiffness and gap of the rigid gapped supports.

C.I.3.12.6.6 ***Use of Snubbers***

If the applicant proposes to use hydraulic snubbers for piping support, the design and analyses should be consistent with Section C.I.3.9.3.2 of this guide.

C.I.3.12.6.7 ***Pipe Support Stiffnesses***

The applicant should discuss and describe pipe support stiffness values and support deflection limits used in the piping analyses and support designs.

C.I.3.12.6.8 ***Seismic Self-Weight Excitation***

This section should describe the design and analyses with consideration of the service loading combination resulting from postulated events and the designation of appropriate service limits for pipe support seismic loads.

C.I.3.12.6.9 ***Design of Supplementary Steel***

The applicant should describe the design and analysis of structural steel used as pipe supports. The design of pipe support from structural steel should be in accordance with Subsection NF of Section III of the ASME Code and AISC N690 (1994) including Supplement 2 (2004).

C.I.3.12.6.10 ***Consideration of Friction Forces***

For sliding type of supports, the applicant should describe and analyze the friction loads induced by the pipe on the support.

C.I.3.12.6.11 ***Pipe Support Gaps and Clearances***

This section should provide information on pipe support gaps and clearances to be used between the pipe and the frame type of support.

C.I.3.12.6.12 ***Instrumentation Line Support Criteria***

The applicant should provide the design criteria for instrumentation line supports. The design loads and load combinations for safety-related instrumentation supports are similar to those for pipe supports. The design for instrumentation line support should be in accordance with criteria described in ASME Code Section III, Subsection NF.

C.I.3.12.6.13 ***Pipe Deflection Limits***

The applicant should provide and describe the pipe deflection limits for standard component pipe supports. The standard component pipe support movement should remain within the manufacturer's recommended design limits. This criterion applies to limit stops, snubbers, rods, hangers, and sway struts.

C.I.3.13 *Threaded Fasteners (ASME Code Class 1, 2, and 3)*

The applicant should provide the criteria used to select materials to fabricate threaded fasteners (e.g., threaded bolts, studs) in ASME Code Class 1, 2, or 3 systems, as well as the criteria to fabricate, design, test, and inspect the threaded fasteners in these systems, both before initial service and during service.

C.I.3.13.1 **Design Considerations**

C.I.3.13.1.1 ***Materials Selection***

The applicant should provide information pertaining to the selection of materials and material testing of threaded fasteners and indicate the level of conformance with applicable codes or standards. For threaded fasteners made from ferritic steels (i.e., low-alloy steel or carbon grades), the applicant should discuss the material testing used to establish the fracture toughness of the materials.

C.I.3.13.1.2 ***Special Materials Fabrication Processes and Special Controls***

The applicant should provide information pertaining to the fabrication of threaded fasteners. It should identify particular fabrication practices or special processes used to mitigate the occurrence of stress-corrosion cracking or other forms of material degradation in the fasteners during service. The discussion should include any environmental considerations related to the selection of materials used to fabricate threaded fasteners. The applicant should discuss the use of lubricants and/or surface treatments in mechanical connections secured by threaded fasteners.

C.I.3.13.1.3 ***Fracture Toughness Requirements for Threaded Fasteners Made of Ferritic Materials***

For threaded fasteners in ASME Code Class 1 systems that are fabricated from ferritic steels, the applicant should discuss the fracture toughness tests performed on the threaded fasteners and demonstrate compliance with applicable acceptance criteria set forth in Appendix G, “Fracture Toughness Requirements,” to 10 CFR Part 50.

C.I.3.13.1.4 ***[Reserved]***

C.I.3.13.1.5 ***Certified Material Test Reports***

The applicant should summarize the material fabrication results and material property test results in the certified material test reports, pursuant to Section III of the ASME Code, Division 1.

C.I.3.13.2 **<u>Inservice Inspection Requirements</u>**

The applicant should demonstrate compliance with the inservice inspection requirements of 10 CFR 50.55a and Section XI of the ASME Code, Division 1.

If the preservice inspections, fracture toughness testing, or certified material test reports are incomplete at the time the COL application is filed, the applicant should describe the implementation program, including milestones, completion dates and expected conclusions.