CONTENTS

LIST OF FIGURES

No figures were included in this chapter.

LIST OF TABLES

3 DESIGN OF STRUCTURES, SYSTEMS, COMPONENTS, AND EQUIPMENT

3.4 Water Level (Flood) Design

3.4.1 Internal Flood Protection

3.4.1.1 *Introduction*

The U.S. EPR includes measures for protecting safety-related equipment against the effects of flooding that could occur inside the plant from postulated flooding sources. The U.S. EPR Final Safety Analysis Report (FSAR) states that because of these measures, a failure of components due to an internal flooding event will not prevent safe shutdown of the plant or mitigation of the flooding event. The review of the plant internal flood protection capability includes all structures, systems, and components (SSCs) whose failure could prevent safe-shutdown of the plant or result in an uncontrolled release of significant radioactivity. The FSAR provides the facility design and equipment arrangements to mitigate internal floods from both internal (e.g., pipe break, tank failure) and external (e.g., failure of exterior tanks) causes.

3.4.1.2 *Summary of Application*

The FSAR describes internal flood protection as follows:

FSAR Tier 1: Internal flood protection is addressed in FSAR Tier 1, Section 2.1.1, "Nuclear Island Structures," The leakage detection system in FSAR Tier 1, Section 2.4.8, "Leakage Detection System," influences flooding accident mitigation by detecting leakage inside containment.

FSAR Tier 2: FSAR Tier 2, Section 3.4.1, "Internal Flood Protection," and FSAR Tier 2, Section 3.4.3, "Analysis of Flooding Events," provide information on measures for protecting safety-related equipment against the effects of flooding that could occur inside the plant. Internal flood protection features described in this section are designed to withstand the effects of flooding and protect SSCs so that they can perform their safety-related functions to mitigate the consequences of postulated accidents.

ITAAC: Internal flood protection ITAAC for the NI buildings are addressed in FSAR Tier 1, Table 2.1.1-4, "Nuclear Island Inspections, Tests, Analyses, and Acceptance Criteria." FSAR Tier 2, Section 14.3, "Inspection, Test, Analysis, and Acceptance Criteria," specifically FSAR Tier 2, Section 14.3.2, FSAR Tier 1, Chapter 2, "System Based Design Descriptions and ITAAC," and FSAR Tier 2, Table 14.3-4, "Flooding Analysis (Safety-Significant Features)," describe a safety significance evaluation of internal flooding. The ITAAC Screening Summary, FSAR Tier 2, Table 14.3-8, "ITAAC Screening Summary," includes the NI structural system, which addresses internal flood protection.

3.4.1.3 *Regulatory Basis*

The relevant requirements of NRC regulations for this area of review, and the associated acceptance criteria, are provided in Section 3.4.1, "Internal Flood Protection for Onsite Equipment Failures," of NUREG-0800, "Standard Review Plan (SRP) for the Review of Safety

Analysis Reports for Nuclear Power Plants – LWR Edition,” (hereafter referred to as NUREG-0800 or the SRP) and are summarized below. Review interfaces with other SRP sections also can be found in SRP Section 3.4.1.

1. The requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Appendix A, “General Design Criteria for Nuclear Power Plants,” General Design Criterion (GDC) 2, “Design Bases for Protection Against Natural Phenomena,” relate to SSCs important to safety being designed to withstand the effects of natural phenomena, such as earthquakes, tornados, hurricanes, floods, tsunami, and seiches without loss of capability in order to perform their safety functions. SSC design bases must reflect appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena.

2. The requirements of 10 CFR Part 50, Appendix A, GDC 4, “Environmental and Dynamic Effects Design Bases,” relate to SSCs important to safety being designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents (LOCAs). The effects of normal and accident conditions considered could include the effects of flooding from full circumferential failures of seismically designed piping as well as non-seismic, moderate-energy piping, which are not considered in SRP Section 3.6.2, “Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping.”

Acceptance criteria adequate to meet the above requirements include the following:

1. Guidance acceptable for meeting the seismic design and classification requirements of GDC 2 is found in Regulatory Guide (RG) 1.29, “Seismic Design Classification,” Position C.1 for safety-related SSCs and Position C.2 for non-safety-related SSCs.

2. With respect to flooding, the requirements of GDC 4 are met if SSCs important to safety are designed to accommodate the effects of discharged fluid resulting from high and moderate energy line breaks that are postulated in SRP Section 3.6.1, “Plant Design for Protection Against Postulated Piping Failures in Fluid Systems Outside Containment,” and SRP Section 3.6.2.

3.4.1.4 *Technical Evaluation*

The staff reviewed the internal flood protection described in the U.S. EPR FSAR Tier 1 and Tier 2, Revision 0, information in accordance with NUREG-0800, Section 3.4.1, “Internal Flood Protection for Onsite Equipment Failures,” Revision 3, March 2007. The staff’s review addressed the overall design for plant internal flood protection, including safety-related SSCs whose failure as a result of flooding could prevent safe-shutdown or result in an uncontrolled release of radioactivity. The results and conclusions of the review are discussed below. Note: External flood protection is discussed under Section 2.4 and Section 3.4.2 of this report. FSAR Tier 2, Section 3.4, “Water Level (Flood) Design,” describes measures for protecting safety related SSCs against the effects of flooding that could occur inside the plant. FSAR Tier 2, Section 3.4.1, “Internal Flood Protection,” provides the facility design and equipment arrangements to mitigate internal floods from both internal (e.g., pipe break, tank failure) and external (e.g., failure of exterior tanks) equipment failures. The principal protective measure for Seismic Category I buildings (including those SSCs that must be designed to remain functional if a safe-shutdown earthquake occurs) is the physical separation of redundant safe-shutdown systems and components. The plant arrangement provides divisional separation walls to physically separate the redundant divisions of safe-shutdown systems and components. According to the applicant, an internal flood in one safety-related division would not affect the other divisions. The Containment Building and the Annulus are not divisionally separated, but provide lower elevation reservoir volumes to receive flood water, and elevated equipment arrangements to mitigate the resulting flood level. The environmental effect of a pipe rupture on safety-related systems is addressed in FSAR Tier 2, Section 3.6.1, "Plant Design for Protection against Postulated Piping Failures in Fluid Systems Outside of Containment," Revision 3, and is evaluated in Section 3.6.1 of this report. The effect of flooding from these piping failures is addressed in FSAR Tier 2, Section 3.4.1 and Section 3.4.2 and is evaluated in this section.

GDC 2 and SSCs for Flood Protection: GDC 2 requires, in part, that "structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena such as … floods … without loss of capability to perform their safety functions." The staff reviewed the safety-related SSCs that must be protected against flooding in accordance with SRP Section 3.4.1, Subsection I.1, and the location of the safety-related SSCs relative to the internal flood level in accordance with SRP Section 3.4.1, Subsection I.2. FSAR Tier 2, Section 3.4.3.1, "Internal Flooding Events," indicates its flood analysis includes an identification of safety-related equipment. However, the results of this identification were not shown in the FSAR Tier 2, Section 3.4.1. In a request for additional information (RAI) 118, Question 03.04.01-4(a), the staff requested that the applicant provide the above information. Furthermore, in RAI 118, Question 03.04.01-4(b), the staff requested that the applicant identify the elevation levels of the safety-related SSCs.

In a December 1, 2008, response to RAI 118, Question 03.04.01-4(a), the applicant proposed to revise the FSAR to reflect that FSAR Tier 2, Section 3.2, "Classifications of Structures, Components, and Systems," FSAR Tier 2, Table 3.2.2-1, "Classification Summary," be referenced by FSAR Tier 2, Section 3.4.1 as the SSCs that must be protected against flooding. Since FSAR Tier 2, Table 3.2.2-1 lists all the safe-related SSCs, the staff finds the response to RAI 118, Question 03.04.01-4(a) acceptable, because the necessary information will be documented in FSAR Tier 2, Section 3.4. The staff has confirmed that Revision 1 of the FSAR, dated May 29, 2009, was revised as committed in the RAI response. Accordingly, the staff finds that the applicant has adequately addressed this issue and, therefore, the staff considers RAI 118, Question 03.04.01-4(a) resolved.

In a December 1, 2008, response to RAI 118, Question 03.04.01-4(b), the applicant indicated that the safe-shutdown systems and components are located at elevations above the flood level. The staff determined the response not acceptable in two areas. First, the response addressed only safe-shutdown SSCs, not safety-related SSCs for flood protection. Second, the response did not clearly specify elevation levels of safety-related SSCs to allow the staff to review and verify the statement that all safety-related SSCs are, indeed, above the flood level.

During a February 19, 2009, audit, the applicant indicated that the design has not reached the stage to provide such design details. In a February 26, 2009, response to RAI 118, Question 03.04.01-7, the applicant proposed to add a combined license (COL) information item and an ITAAC to state that, "essential equipment required for safe-shutdown located in the Reactor Building (RB) and [Reactor Building Annulus] RBA is located above the internal flood level or is designed to withstand flooding," (FSAR Tier 1, Table 2.2.2-7, Item No. 4.11 and FSAR Tier 2, Table 1.8-2, "U.S. EPR Combined License Information Items," COL Information

Item 3.4-5). The staff finds that the addition of the COL information item and ITAAC inspection is acceptable to address the staff concern identified in RAI 118, Question 03.04.01-4(b) relative to the unavailability of elevation levels for the safety-related SSCs.

However, in reviewing the response, the staff identified inadequacies in the wording of the COL information item and the ITAAC. These inadequacies are identified in the following two RAIs. First, the COL information item and the ITAAC would allow submerged operation of safety related SSCs. This is inconsistent with the responses to RAI 109, Questions 03.04.01-1 and RAI 118, 03.04.01-4, which do not allow submerged operation. This resulted in issuance of follow-up RAI 218, Question 03.04.01-8. In RAI 218, Question 03.04.01-8, the staff requested that the applicant resolve the above inconsistency. In a May 15, 2009, response to RAI 218, Question 03.04.01-8, the applicant deleted the wording in the ITAAC that could allow submerged operation of safety-related SSCs. Further, the applicant stated that no submerged SSCs perform a safety-related function for safe shutdown of the plant or to mitigate the consequences of an accident. This clarification and ITAAC wording change eliminate the inconsistency with respect to submerged operation, and is considered acceptable. **RAI 218, Question 03.04.01-8 is being tracked as a confirmatory item** to ensure the FSAR is revised accordingly.

Second, the SSCs being protected from flooding included only safe shutdown SSCs, rather than all safety-related components. The staff requested that the applicant clarify what SSCs are being protected from flooding. This resulted in issuance of follow-up RAI 218, Question 03.04.01-9. In a May 15, 2009, response to RAI 218, Question 03.04.01, the applicant clarified that the SSCs being protected from flooding include SSCs not only for safe shutdown but also for accident mitigation. Further, the applicant stated that the SSCs being protected from flooding are consistent with those specified in SRP Section 3.4.1. Accordingly, the staff finds that the applicant has adequately clarified this issue and, therefore, the staff considers RAI 218, Question 03.04.01-9 resolved.

SRP Section 3.4.1, Acceptance Criterion 1 identifies GDC 2 as being an acceptance criterion for internal flooding. FSAR Tier 2, Section 3.4 states that in accordance with GDC 2 and RG 1.29, the Seismic Category I SSCs identified in FSAR Tier 2, Section 3.2 can withstand the effects of flooding due to natural phenomena or onsite equipment failures, without losing the capability to perform their safety-related functions. FSAR Tier 2 Section 3.4 concludes, therefore, that the U.S. EPR is designed to meet GDC 2. Specifically, how the safety-related SSCs in different areas of the plant are protected from flooding is discussed in FSAR Tier 2, Sections 3.4.1 through 3.4.10, and is evaluated below.

Physical Separation and Building Layout: The staff reviewed the building layout provided in FSAR Tier 2, Section 3.8, "Design of Category I Structures," and physical separation in FSAR Tier 2, Section 3.4.1. FSAR Tier 2, Section 3.4.1 states that the Nuclear Island Seismic Category I buildings located on the NI common basemat are divisional buildings designed with physical separation between them. The physical separation is used as the internal flood protection measure for these buildings. The NI buildings are the Reactor Shield Building (RSB) and Annulus, Fuel Building (FB), and Safeguard Buildings 1, 2, 3, and 4. The other safety-related buildings with divisional separation are the Emergency Power Generating Buildings (EPGB 1, 2, 3, and 4) and the Essential Service Water Buildings (ESWB 1, 2, 3, and 4), which house the Essential Service Water Cooling Towers (ESWCT) and the Essential Service Water Pump Buildings (ESWPB). The divisional buildings typically are designed for flooding up to Elevation +0 m (+0 ft). The plant arrangement drawings were reviewed, and the staff confirmed that the plant layout, with some exceptions to be discussed below, does provide divisional separation to physically separate the redundant divisions of safe-shutdown systems and components. Accordingly, the staff determined that internal flooding in one safety-related division would not affect the other divisions with the exceptions discussed below.

FSAR Tier 2, Section 3.4.1 states that the principal protective measure for Seismic Category I buildings is physical separation of the redundant safe-shutdown systems and components. FSAR Tier 2, Section 3.4.1 indicates as follows: The plant arrangement provides divisional separation walls to physically separate the redundant divisions of safe-shutdown systems and components. Division walls below Elevation +0 m (+0 ft) provide separation and serve as flood barriers. These division walls are watertight, have no doors, and have a minimum number of penetrations. Above Elevation +0 m (+0 ft), a combination of watertight doors and openings for water flow to the lower building levels prevents water ingress into adjacent divisions. Watertight doors have position indicators for identification of the closed position. Based on the above FSAR information, the staff has determined that watertight doors are an important design feature for internal flood protection.

SRP Section 3.4.1, Subsection III.2 provides guidance for the staff to evaluate the adequacy of flood protection features including watertight doors. The staff was not able to find information in the FSAR about door seal design, seal degradation due to aging, and maintenance requirements for door seals. In RAI 118, Question 03.04.01-5, the staff requested that the applicant provide this information about the door seals to ensure that water tight doors serve their intended flood protection function. In a December 1, 2008, response to RAI 118, Question 03.04.01-5, the applicant stated that water-resistant door design details are to be specified later in the design process and that water-resistant doors would be designed and engineered to meet leak-rate limits, door-seal aging-degradation characteristics, and maintainability. The applicant stated that maintenance requirements would be based on manufacturer recommendations and that maintenance procedures would be prepared by COL applicants in accordance with their respective regulatory-approved maintenance programs. The staff determined that the commitment for seal design to meet leakage limits with maintenance based on manufacturer recommendations acceptable. However, the applicant did not identify a COL information item as described in the RAI response. Follow-up RAI 218, Question 03.04.01 10 requested that the applicant provide a COL information item to ensure these doors and seals are designed as stated. In a June 12, 2009, response to RAI 218, Question 03.04.01-10, the applicant stated that implementation of the maintenance program is the responsibility of the COL applicant. The staff agrees with the applicant's determination, however, the applicant did not identify a COL information item as described in the RAI response. As a result, in RAI 377, Question 03.04.01-13, the staff requested that the FSAR identify a COL information item so that the COL applicant can address the issue of watertight doors in the COLA. **RAI 377, Question 03.04.01-13, which is associated with the above request, is being tracked as an open item**.

Reactor Building and Containment: The staff reviewed the adequacy of the flood protection of safety-related systems and equipment in structures that are not designed with divisional separation between redundant divisions. The applicable structure without divisional separation is the RB. The RB layout was reviewed to determine if it allows water released inside the building to flow to the lower level of the building. Inside the Containment Building, water will flow down to the in-containment refueling water storage tank.

The RB containment and Annulus are not divisionally separated but provide lower elevation reservoir volumes to receive flood water, and elevated equipment arrangements to mitigate the resulting flood level. In these cases, the elevation of the safety-related SSCs relative to the internal flood level in the RB becomes an important flood protection measure. FSAR Tier 2, Section 3.4.3.3, “Reactor Building Flood Analysis,” reports that an analysis was performed and concluded that flooding events will result in flood levels less than Elevation -1.3 m (-4 ft, 3 in.) in the Containment Building and Elevation +0 m (+0 ft) in the Annulus. FSAR Tier 2, Section 3.4.1 states that safety-related systems and components in these structures are located above the maximum water level. However, there was insufficient information in the FSAR for the staff to verify this statement. FSAR Tier 2, Section 3.4.3.1 outlined the flood analysis, but did not provide sufficient details for the staff to review the analysis. In RAI 118, Question 03.04.01-6, the staff requested that the applicant address the potential flood sources, the bounding case determination for flooding, and the resulting flood level analysis.

The staff determined that the applicant’s December 1, 2008, response to RAI 118, Question 03.04.01-6, did not fully address these questions. In a February 19, 2009, audit, the staff reviewed the associated design calculation document. While the flood analysis appeared to be acceptable, it has not yet been submitted on the docket for staff review. The staff identified necessary flood analysis information in the calculation that needs to be included in the RAI response and FSAR. In follow-up RAI 218, Question 03.04.01-11, the staff requested that the applicant provide the methodology including this flood analysis information in a follow-up RAI response and in a revision to the FSAR. In a May 15, 2009, response to RAI 218, Question 03.04.01-11, the applicant stated that FSAR Tier 2, Table 3.4-1, would be added to list the water-carrying piping systems located in the RB and the RBA, which are considered potential internal flooding sources in the flooding analysis of the respective buildings. Additionally, the applicant provided more details on the flood analysis in the RAI responses. The staff reviewed this information and determined that the applicant assessed limiting pipe breaks and flood mitigation measures incorporated in the design. Accordingly, the response to RAI 218, Question 03.04.01-11 adequately addressed the staff’s concern. **RAI 218, Question 03.04.01-11 is being tracked as a confirmatory item** to ensure the FSAR is revised accordingly.

GDC 4 and GDC 2, Pipe Breaks Assumed for Flood Protection: SRP Section 3.4.1 states that the requirements of GDC 4 are met if SSCs important to safety are designed to accommodate the effects of discharged fluid resulting from high and moderate energy line breaks that are postulated in SRP Sections 3.6.1 and 3.6.2. In addition, the requirements of GDC 2 relate to the SSCs important to safety being designed to withstand the effects of natural phenomena such as earthquakes and flood without loss of capability to perform their safety functions. SSC design bases must reflect appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena. The effects of normal and accident conditions considered could include the effects of flooding from full circumferential failures of non-seismic, moderate-energy piping. FSAR Tier 2, Section 3.4.3.3 states that the applicant performed an analysis, and determined that the maximum flood level in the containment is Elevation -1.3 m (-4 ft, 3 in.). The breaks considered in FSAR Tier 2, Section 3.4.3.3 are loss-of-coolant accident (LOCA), main steamline break, main feedwater line break, and fire water distribution pipe break. As stated in that section, the bounding pipe break that defines the volume of water used in the analysis is the fire water pipe break. FSAR Tier 2, Section 3.4.3.3 states that flooding inside containment due to leakage is detected by measuring humidity, temperature, condensate flow, and water levels in drain and vent collection tanks or sumps. The protection system initiates automatic measures to cope with the flooding. A high level sump alarm in the main control room (MCR) notifies the operator to close the isolation valves. The operator action is assumed to be taken within 30 minutes.

The staff reviewed the above information and could not confirm that the applicant has considered all potential water sources under GDC 4 (all high and moderate energy line breaks that are postulated in SRP Sections 3.6.1 and 3.6.2) and GDC 2 (all non-seismic, moderate energy line breaks). In addition, the staff could not identify how the applicant made its determination of the bounding pipe break being the fire distribution line. Also, the FSAR did not have sufficient information for the staff to review the applicant calculation of flood level. This was identified in RAI 118, Question 03.04.01-6, as discussed above.

FSAR Tier 2, Section 3.4.3.3 indicates that the safe-shutdown components at the lowest elevation in containment are those in the safety-injection system/residual heat removal system (SIS/RHRS), containment isolation valves, and reactor protection system. These safety-related components are located above flood level, Elevation -1.3 m (-4 ft, 3 in.). Alternatively, if safety related equipment is located below this elevation, they are qualified for operation when flooded.

The staff reviewed the above information in accordance with SRP Section 3.4.1 and identified the following two RAIs:

First, to verify the proper elevation of these design features, a specific flooding walk-down needs to be added to the ITAAC to verify that all safety-related SSCs in the RB are located above the flood level (RAI 118, Question 03.04.01-7). In a February 26, 2009, response to RAI 118, Question 03.04.01-7, the applicant proposed to add additional FSAR Tier 1 ITAAC commitments (i.e., to FSAR Tier 1, Table 2.1.1-4) to perform internal flood protection analyses and walk-downs. Additionally COL information items were added to FSAR Tier 2, Table 1.8-2 to perform an internal flooding analysis prior to fuel load. The staff finds the February 26, 2009, response to RAI 118, 03.04.01-7 acceptable with respect to providing specific ITAAC to verify that all safety-related SSCs in the RB are located above the flood level. The staff has confirmed that FSAR Tier 1 and Tier 2, Revision 1, dated May 29, 2009, included the commitment in the RAI response. Since the applicant added an ITAAC to govern this matter, the staff finds that the applicant has adequately addressed this issue and, therefore, the staff considers RAI 118, Question 03.04.01-7 resolved in this regard.

Second, the staff finds that the statement in FSAR Tier 2, Section 3.4.3.3 that, "if safety-related equipment is located below the flood level, it must be qualified for operation when flooded," does not recognize the need for staff review of the operability of submerged SSCs. In accordance with SRP Section 3.4.1, Review Procedure No. 5, the safety-related SSCs being located below the flood level should be reviewed and, therefore, should be identified in the FSAR, and their qualification program should be described in the FSAR for the staff to review. Exceptions, if any, should be justified in the FSAR. It is not clear whether the U.S. EPR flood protection design includes the option of submerged SSC operation. If it is to be allowed in the certified design, the applicant is requested to provide the above information in the FSAR. However, if it is to be an option for COL applicants, the applicant is requested to identify a COL information item to provide the above information for COL applicants to use this option. Without an adequate staff review, the option of submerged SSC operation is not acceptable. This issue was identified in RAI 109, Question 03.04.01-1. In a December 15, 2008, response to RAI 109, Question 03.04.01-1, the applicant proposed to revise FSAR Tier 2, Section 3.4.3.3, "Reactor Building Flooding Analysis," to state that there are no safety-related SSCS that perform safety related functions while being completely or partially flooded. However, in a February 26, 2009, response to RAI 118, Question 03.04.01-7, the applicant revised its position and stated that, "essential equipment required for safe-shutdown located in the RB and RBA is located above the internal flood level or is designed to withstand flooding" (FSAR Tier 1, Table 2.1.1-4, Item No. 4.11). The submerged operation of safety-related SSCs should be subject to prior NRC review as discussed in RAI 109, Question 03.04.01-1. The responses to these two RAIs regarding the operation of submerged SSCs are inconsistent. In RAI 218, Question 03.04.01-8, the staff requested that the applicant resolve the inconsistency between its responses to RAI 109, Question 03.04.01-1 and RAI 118, Question 03.04.01-7. In RAI 218, Question 03.04.01-9, the staff requested that the applicant address the need for the NRC review of the submerged SSCs. RAI 218, Questions 03.04.01-8 and 03.04.01-9, have been resolved as discussed above, since there are no safety-related SSCS that perform safety-related functions while being completely or partially flooded, **RAI 218, Questions 03.04.01-8 and 03.04.01-9 are being tracked as confirmatory items**.

Annulus: FSAR Tier 2, Section 3.4.3.3 describes that the RB annulus is a single volume being considered as one room for the purpose of flood protection. Internal flooding water flows to the bottom level where it is retained. The annulus is analyzed for flood waters below Elevation +0 m (+0 ft). Safety-related systems and components located in the annulus consist of plug-boxes of electrical penetrations. They are located well above the +0 level (i.e., at Elevation +5 m (16 ft)). All safety-related structures are described to be located above the internal flooding maximum water level. The postulated break in the fire water distribution system is the bounding case for the maximum water volume released to the annulus. The maximum possible fire water pump capacity, a sump level alarm in the MCR, and the assumed 30-minute operator response time to close the isolation valves define the volume which results in a level estimated to be below the +0 elevation level. This flood level can make the normal annulus and SB controlled area ventilation system inoperable, but none of the safety-related functions associated with the annulus area are affected. The staff reviewed the above FSAR information and identified questions similar to the ones in the discussion of "Reactor Building and Containment," as related to the methodology of the flood analysis. This was issued as RAI 118, Question 03.04.01-6, and resolved through follow-up up RAI 218, Question 03.04.01-11, which was as discussed above in the paragraph of "Reactor Building and Containment."

Divisional Buildings: FSAR Tier 2, Section 3.4.1 states that that divisional walls in NI safety-related buildings (other than the RB) below Elevation +0 m (+0 ft) serve as flood barriers to prevent flood waters spreading to adjacent divisions. FSAR Tier 2, Section 3.4.1 states as follows: These division walls are designed to be watertight with no doors and a minimal number of penetrations. Floods occurring within one divisional building should be contained in that building at an Elevation below +0 m (+0 ft). The flood protection design for the divisional buildings is that the division with the pipe break is considered to be inoperable due to flooding, but the adjacent division is not impacted by the flood.

Above Elevation +0 m (+0 ft), a combination of watertight doors and openings for water flow to the lower building levels should prevent water ingress into adjacent divisions as follows:

- Watertight doors have position indicators for indication of the closed position.
- Existing openings (e.g., staircases, elevator shafts, and building drains) are credited as water flow paths when available.

- Flooding pits with burst openings collect and direct water flow to lower building levels.
- Rooms within divisional buildings have interconnections so that the maximum released water volume can be distributed and stored in the lower building levels of the affected division.
- Interconnections include doors with flaps, wall openings, and other wall penetrations that are not sealed.
- Elevated thresholds, curbs, and pedestals are provided as necessary.

The divisionally separated buildings are not interconnected, with the following exceptions:

- SB Divisions 2 and 3 have interconnected passageways in some of the floor elevations, but they are all above Elevation +0 m (+0 ft) and are part of the safety-related SB.
- SB Division 1 has passageways connected with the Fuel Building (divisionally separated below Elevation +0 m (+0 ft) and designated FB 1 and FB 2).
- SB 1 connects to FB 1, but the connections are all below Elevation +0 m (+0 ft) and are part of the same safety-related Division 1.
- Likewise, SB Division 4 and FB 2 have interconnections below Elevation +0 m (+0 ft) and are part of the same Division 4.
- The NI drains and vent system (NIDVS) connect some safety-related divisions and non-safety-related areas.

The staff reviewed the above FSAR information of the design features related to the divisional buildings and the plant layout drawings. In RAI 218, Question 03.04.01-12, the staff requested that the applicant explain how the systems can perform their intended safety function, given a failure of one division. In a May 15, 2009, response to RAI 218, Question 03.04.01-12, the applicant stated that the Safeguard Buildings, Emergency Power Generating Buildings, and Essential Service Water Pump Buildings are designed with divisional separation of the four divisions of safety systems and are consistent with an N+2 safety concept. With four divisions, one division can be down for maintenance and one can fail to operate due to an event such as internal flooding, while the remaining two divisions are available and sufficient to perform the necessary safety functions. The FB is designed with complete separation into two divisions below elevation +0 m (+0 feet 0 in.), such that in the event of an internal flood, the flood is restricted to one division of the FB while the other division is available to perform the necessary safety functions. Each of the two divisions is designed to fulfill the safety function assuming the other division is not available. FSAR Tier 2, Section 3.4.1, Sections 3.4.3.8, and 3.4.3.9 will be revised to add statements clarifying these design features. The staff reviewed the response RAI 218, Question 03.04.01-12, and finds it acceptable because the design separates the divisions such that failure of one division of the SSCs would not result in failure of the intended safety function. The staff considers RAI 218, Question 03.04.01-12 resolved. **RAI 218, Question 03.04.01-12 is being tracked as a confirmatory item**.

Floor Drains: The staff reviewed the design features that will be used to mitigate the effects of internal flooding (e.g., floor drainage, sump pumps, etc.). The NIDVS captures floor drainage and provides sumps for removing water. The NIDVS is non-safety-related and is conservatively considered not available for reducing water volume by the respective sump pumps. Where necessary, the NIDVS prevents backflow of water from flooded areas to unaffected areas of the plant that contain safety-related equipment by the use of redundant check valves in series. The staff finds the design of NIDVS acceptable because it provides additional flood mitigation capability beyond what has been used in the flood analysis.

Interconnected Paths: In accordance with SRP Section 3.4.1, the staff reviewed the possible flow paths from interconnected non-safety-related areas to buildings, rooms, and enclosures that house safety-related SSCs (e.g., leakage through interconnecting doorways). The non-safety-related areas included the Nuclear Auxiliary Building (NAB), Radioactive Waste Building (RWB), and access buildings. Based on the layout drawings, the staff finds that the non-safety areas do not connect with the adjacent safety-related building. The NAB and FB 2, and NAB and SB 4 do not interconnect below Elevation +0 m (+0 ft). The Radioactive Waste Building and NAB do interconnect below Elevation +0 m (+0 ft) but only in non-safety-related areas that do not connect to safety-related areas.

To verify these features, the staff finds that a flood protection walk-down should be added to the ITAAC to verify that all safety-related equipment areas were protected from cross-divisional flooding. In RAI 118, Question 03.04.01-7, the staff requested that the applicant provide this ITAAC. In a February 26, 2009, response to RAI 118, Question 03.04.01-7, the applicant provided an ITAAC as requested and, therefore, the staff considers RAI 118, Question 03.04.01-7 resolved.

Main Control Room: The MCR and the remote shutdown station (RSS) are located in the SB. FSAR Tier 2, Section 3.4.3.4, "Safeguard Buildings Flooding Analysis," addresses flood protection for the MCR and RSS. The applicant indicated that potential flooding water from upper levels can be directed through multiple openings and flow paths to lower building levels. In addition, the FSAR discussed the line isolation, leak detection, alarms, and drains for the flood protection. However, it was not clear whether there was a watertight door to protect the MCR and RSS from external water sources. The FSAR discussion did not distinguish external water sources from internal water sources relative to these rooms and the flood protection for each. The staff identified the following questions for the applicant in RAI 109, Question 03.04.01-3:

- Clarify whether there are watertight doors being designed to prevent the external water sources entering into the MCR and RSS. If not, demonstrate the adequacy of the flood protection measures to protect the safety-related SSCs in the MCR and RSS. It should be noted that the flow paths may direct the flooding water into the MCR and RSS through doors.

- The FSAR does not distinguish the source of water being external or internal. Identify all the potential sources of flooding water inside MCR and RSS. Identify in the FSAR all the measures for the flood protection for the internal water sources.

- Are the floor drains inside MCR and RSS the necessary equipment for the flood protection? If not, provide a flood analysis to show the flood level in the MCR and RSS and the location levels of all SSCs in the MCR and RSS. If yes, upgrade the floor drains in the MCR and RSS from being non-safety-related to safety-related or justify the adequacy for being non-safety-related. It should be noted that the current version of the

FSAR treats the floor drains as non-safety-related equipment, because they are not taken into account for any safety analysis.

In a December 15, 2008, response to RAI 109, Question 03.04.01-3, the applicant proposed to revise FSAR Tier 2, Section 3.4.3.4, "Safeguard Buildings Flooding Analysis," to state that there are no water-carrying piping systems located in the MCR and RSS. Additionally, the proposed change states that thresholds are provided for doors entering the MCR, and water resistant doors are provided for entry doors to the RSS. The applicant also responded that:

- There are no sources of water inside the MCR or RSS and, therefore, measures are not required for flood protection from water sources within these rooms. Potential sources of flooding for the MCR and RSS are external to these rooms.

- Floor drains are not relied upon for flood protection of the MCR or RSS. The flood protection strategy is to prevent water from entering these rooms. Therefore, there are no expected flood levels within these rooms, and there are no requirements for designating floor drains as safety related.

The staff reviewed the above explanations and the proposed FSAR changes, and finds that the concerns identified in the RAI are adequately addressed because there is no source of water inside the MCR or RSS and the external source of water is prevented from entering these rooms. The potential flooding water from upper levels can be directed through multiple openings and flow paths to lower building levels. The staff has confirmed that FSAR Tier 2, Revision 1, dated May 29, 2009, was revised as committed in the RAI response. Accordingly, the staff finds that the applicant has adequately addressed this issue and, therefore, the staff considers RAI 109, Question 03.04.01-3 resolved.

Flood Protection in the Emergency Power Generating Buildings: The staff reviewed the flood protection in the EPGBs, which house the emergency diesel generators, fuel oil storage, and the associated Class 1E Electrical Equipment. FSAR Tier 2, Section 3.4.3.8, "Emergency Power Generating Buildings Flooding Analysis," states that postulated pipe breaks in water-carrying systems were considered in the flood analysis for the maximum flood level determination. The divisional separation wall between the EPGBs is designed as a flood barrier up to the maximum flood level. As a result of the review, the staff requested that the applicant clarify the following in the FSAR: 1) What the "water-carrying systems" are which were considered for breaks; 2) which system is bounding; 3) what is the maximum flood level; and 4) what are the elevations for the SSCs which are subject to flood protection. In addition, in RAI 109, Question 03.04.01-2, the staff requested that the applicant provide the analysis with all the assumptions for the maximum flood level calculation in the EPGBs.

In a December 15, 2008, response to RAI 109, Question 03.04.01-2, the applicant proposed to revise FSAR Tier 2, Section 3.4.3.8, "Emergency Generating Buildings Flooding Analysis," to state the specific system pipe breaks that are considered in the flooding analysis within the EPGB, state the bounding internal flooding source, which is a pipe break in the fire water distribution system, and state that the maximum flood level is 5.18 m (17 ft). The applicant also proposed to revise the FSAR to state that: The divisional separation wall between the EPGBs is designed as a flood barrier and is higher than the bounding maximum flood level; that piping and cable penetrations between EPGB divisions are watertight; and that internal flooding is restricted to one EPGB division which is assumed unavailable. The staff determined that this statement that the internal flood is restricted to one EPGB was inconclusive in explaining the adequacy of the flood protection for the EPGBs, and the applicant needed to explain further why the remaining EPGBs are sufficient to perform the intended safety function. In RAI 218, Question 03.04.01-12, the staff requested that the applicant explain the above question.

In a May 15, 2009, response to RAI 218, Question 03.04.01-12, the applicant stated that FSAR Tier 2, Section 3.4.1, Section 3.4.3.8, and Section 3.4.3.9 will be revised to add statements clarifying these design features of the divisional buildings for flood protection. The staff reviewed the above RAI response and found it acceptable in the paragraph of “Divisional Buildings,” because the response described divisional separation features adequate to address the concern that failure of one division of the SSCs would not result in failure of the intended safety function. The staff considers RAI 218, Question 03.04.01-12 resolved. **RAI 218, Question 03.04.01-12 is being tracked as a confirmatory item**.

In-leakage Sources: The staff reviewed the protection against possible in-leakage sources in accordance with SRP Section 3.4.1. The sources included non-mechanistic cracks in structures and exterior openings and penetrations in structures located at a lower elevation than the postulated internal flood level. The U.S. EPR was found to withstand these effects by the following design features:

- Structures below grade have water stops and waterproofing.
- Penetrations below grade have watertight seals.
- Structures can withstand hydrostatic loads from groundwater pressure.

The staff finds the design for flooding protection from in-leakage sources satisfactory.

External Equipment: The staff reviewed flooding protection in safety-related buildings that are located in the yard buildings external to the NI buildings. These safety-related buildings, which have divisional separation, are the EPGB-1, 2, 3, and 4 and the ESWB-1, 2, 3, and 4. The staff reviewed the site arrangement drawings for equipment that could be postulated as flooding sources. The applicant’s flooding analysis considered a postulated essential service water system (ESWS) pipe failure inside the building and determined that it only affects the division that has a failure. For the EPGB flooding analysis, see the “Flood Protection in the EPGBs” discussion section above. The site grading would prevent equipment (tank) failures in the yard from causing flooding internal to the EPGB and ESWB buildings. The service water exterior piping and the circulating water system (CWS) piping were considered a credible source of flooding. The service water buried piping is laid out on a safety-related divisional basis. A service water buried pipe failure would affect the associated division, and site grading should prevent the adjacent division from being affected (note ESWB-1 and 4 are adjacent and ESWB -2 and -3 are adjacent). A circulating water pipe failure in the yard was reviewed according to SRP Section 10.4.5, “Circulating Water System,” and evaluated in Section 10.4.5 of this report. A circulating water piping failure inside the Turbine Building is discussed in FSAR Tier 2, Section 10.4.5.3, and the water flow does not communicate with the NI or the other safety-related buildings in the yard. The staff finds the safety-related yard buildings are adequately protected from internal flooding as discussed above and in the applicant’s revision to FSAR Tier 2, Section 3.4.3.8, EPGB flooding analysis.

Instrumentation: FSAR Tier 2, Section 3.4 describes the leak detection and isolation measures necessary to mitigate the consequences of postulated pipe ruptures. FSAR Tier 2, Section 3.4 states further: Various methods are used where appropriate (the containment has the most diverse systems) including water level instrumentation, and other leak detection measures that can detect pipe ruptures which could result in internal flooding. These leak detection systems provide a signal to automatically isolate the affected system, or to provide indication in the MCR to initiate operator action from within the MCR or locally, within 30 minutes. The staff reviewed the instrumentation needed for flood protection, including the adequacy of detectors and alarms necessary to detect rising water levels within structures and the consequences of flooding on other safety-related instrumentation and electrical equipment. Based on the above FSAR information, the staff finds the described instrumentation is adequate for flood protection.

ITAAC: The staff reviewed FSAR Tier 1 and did not find a section discussing internal flood protection. The regulation in 10 CFR 52.47(b)(1), "Contents of applications; technical information," requires that a design certification application contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the design certification is built and will operate in accordance with the design certification, the provisions of the Atomic Energy Act, and NRC regulations. FSAR Tier 2, Section 3.4.1, describes a flood-protection design to meet GDC 2 and GDC 4. SRP Section 3.4.1, Acceptance Criterion 3, asks the applicant to provide an ITAAC to verify the plant is built in accordance with the design certification. In RAI 118, Question 03.04.01-7, the staff requested that the applicant provide additional ITAAC to verify that all important design features described in FSAR Tier 2, Section 3.4, for flood protection are properly implemented. ITAAC walk-downs should verify safety-related SSCs are above the flood level in the Reactor Building. In all buildings containing safety-related equipment, ITAAC should verify barrier integrity below the flood level (e.g., Elevation +0 m (+0 ft)) and should verify that the flood protection design features above the flood level (e.g., Elevation +0 m (+0 ft)) are properly implemented.

In a February 26, 2009, response to RAI 118, Question 03.04.01-7, the applicant proposed adding FSAR Tier 1 ITAAC commitments for internal flood protection with specific internal flood analyses and walk-downs (FSAR Tier 1, Table 2.1.1-4). Additionally, the applicant proposed adding COL information items to the FSAR Tier 2, Table 1.8-2 to perform an internal flooding analysis prior to fuel load. This is a confirmatory analysis of the one being reviewed and found acceptable in RAI 218, Question 03.04.01-11. The staff reviewed the applicant's response to RAI 118, Question 03.04.01-7, including the proposed ITAAC, and found it included the information that was requested in the RAI. The staff finds the applicant's proposed revisions to the FSAR to be acceptable. The staff has confirmed that FSAR Tier 1 and Tier 2, Revision 1, dated May 29, 2009, was revised as committed in the RAI response. Accordingly, the staff finds that the applicant has adequately addressed this issue and, therefore, the staff considers RAI 118, Question 03.04.01-7 resolved.

3.4.1.5 *Combined License Information Items*

Table 3.4.1-1 provides a list of internal flood protection related COL item numbers and descriptions from FSAR Tier 2, Table 1.8-2:

Table 3.4.1.5-1 U.S. EPR Combined License Information Items

Item No.	Description	FSAR Tier 2 Section
3.4-1	A COL applicant that references the U.S. EPR design certification will confirm the potential site specific external flooding events are bounded by the U.S. EPR design basis flood values or otherwise demonstrate that the design is acceptable.	3.4.3.2
3.4-2	A COL applicant that references the U.S. EPR design certification will perform a flooding analysis for the ultimate heat sink makeup water intake structure based on the site-specific design of the structures and the flood protection concepts provided herein.	3.4.3.10
3.4-3	A COL applicant that references the U.S. EPR design certification will define the need for a site-specific permanent dewatering system.	3.4.3.11
3.4-4	A COL applicant that references the U.S. EPR design certification will perform internal flooding analyses prior to fuel load for the Safeguard Buildings and Fuel Building to demonstrate that the impact of internal flooding is contained within the Safeguard Building or Fuel Building division of origin.	3.4.1
3.4-5	A COL applicant that references the U.S. EPR design certification will perform an internal flooding analysis prior to fuel load for the Reactor Building and Reactor Building Annulus to demonstrate that the essential equipment required for safe shutdown is located above the internal flood level or is designed to withstand flooding.	3.4.1

Notes:

1. FSAR Tier 2, Section 3.4.3.11, "Permanent Dewatering System," indicates that the U.S. EPR design does not include a permanent dewatering system to protect safety related SSCs from below-grade groundwater seepage. The need for a permanent dewatering system will be addressed by the COL applicant. This is identified as a COL information item as listed in FSAR Tier 2, Table 1.8-2, Item Number 3.4-3. This COL information item was reviewed by the staff and found acceptable as related to SRP Section 2.4.

2. FSAR Tier 2, Section 3.4.3.10, "Ultimate Heat Sink Makeup Water Intake Structure Flooding Analysis," indicates that a COL applicant that references the U.S. EPR design will perform a flooding analysis for the ultimate heat sink makeup water intake structure based on the site-specific design of the structures and the flood protection concepts provided herein. This is identified as a COL information item as listed in FSAR Tier 2, Table 1.8-2, Item No. 3.4-2. This COL information item was reviewed by the staff and found acceptable as related to SRP Section 2.4.

3. A potential unidentified COL information item associated with the commitment for the seals design to meet leakage limits by maintenance is discussed above, and is related to RAI 377, Question 03.04.01-13. **RAI 377, Question 03.04.01-13 is being tracked as an open item**.

With the exception of the items noted above, the staff finds the above list of COL information items to be complete, and adequately describes the actions necessary for the COL applicant.

3.4.1.6 *Conclusions*

The staff reviewed the U.S. EPR application in accordance with the guidance provided in SRP Section 3.4.1, "Internal Flood Protection." Except for the open items and confirmatory items identified above, the staff concludes that the U.S. EPR internal flooding design is acceptable in accordance with GDC 2 and GDC 4.

3.5 Missile Protection

10 CFR Part 50, Appendix A, GDC 4 requires in part, that SSCs important to safety must be protected against the effects of missiles that may result from equipment failures and from events and conditions outside the plant. GDC 2 requires that SSCs that are important to safety must be designed to withstand the effects of natural phenomena such as tornadoes without loss of capability to perform their safety functions.

3.5.1 Missile Selection and Description

The following are potential missile generating sources in the U.S. EPR design:

- Internally generated missiles effecting SSCs outside containment (FSAR Tier 2, Section 3.5.1.1)
- Internally generated missiles effecting SSCs inside containment (FSAR Tier 2, Section 3.5.1.2)
- Turbine missiles (FSAR Tier 2, Section 3.5.1.3)
- Missiles generated by tornadoes and extreme winds (FSAR Tier 2, Section 3.5.1.4)
- Site proximity missiles (except aircraft) (FSAR Tier 2, Section 3.5.1.5)
- Aircraft hazards (FSAR Tier 2, Section 3.5.1.6)

3.5.1.1 *Internally Generated Missiles Outside Containment*

3.5.1.1.1 Introduction

All SSCs located outside containment are to be protected from internally-generated missiles to ensure compliance with GDC 4 requirements. This includes internally-generated missiles from component overspeed failures, missiles that could originate from high-energy fluid systems failures, and missiles caused by or as a consequence of gravitational effects. An internally generated missile is a dynamic effect of such failures, and its impact on SSCs outside containment that is important to safety must be evaluated. Protecting SSCs located outside containment from the effects of internally generated missiles ensures the capability to shut down and maintain the reactor in a shutdown condition, and the capability to prevent significant uncontrolled release of radioactivity.

3.5.1.1.2 Summary of Application

FSAR Tier 1: There is no FSAR Tier 1 information directly related to internally generated missiles or missile protection for SSCs located outside containment. FSAR Tier 1, Section 2.1.1, FSAR Tier 1, Section 2.1.2, and FSAR Tier 1, Section 2.1.5 describe the design of the NI structures, EPGB, and Essential Service Water Buildings, respectively.

FSAR Tier 2: FSAR Tier 2, Section 3.5.1.1, "Internally Generated Missiles Outside Containment," describes the credible and non-credible internally generated sources and missile protection for SSCs located outside containment. The basis for identifying credible and non-credible missiles is presented along with the design measures to limit missile generation and provide protection to SSCs located outside containment.

ITAAC: FSAR Tier 1, Table 2.1.1-4, "Nuclear Island ITTAC," FSAR Tier 1, Table 2.1.2-3, "Emergency Power Generating Buildings," and FSAR Tier 1, Table 2.1.5-3, "Essential Service Water Building Inspections, Tests, Analyses, and Acceptance Criteria"; provide ITAAC requirements for the Nuclear Island structures, EPGB, and Essential Service Water Buildings, respectively. FSAR Tier 2, Section 14.2, "Initial Plant Test Program," and FSAR Tier 2, Section 14.3, "Inspection, Test, Analysis, and Acceptance Criteria," do not provide any initial testing or ITAAC requirements associated with this review item.

3.5.1.1.3 Regulatory Basis

The relevant requirements of NRC regulations for this area of review, and the associated acceptance criteria, are given in NUREG-0800, Section 3.5.1.1, and are summarized below. Review interfaces with other SRP sections also can be found in NUREG-0800, Section 3.5.1.1.I.

1. GDC 4, as it relates to the design of the SSCs important to safety to protect them against the dynamic effects of internally generated missiles outside containment, requires, in part, that SSCs important to safety shall be appropriately protected against the dynamic effects of internally generated missiles outside containment that may result from equipment failures.

2. 10 CFR 52.47(b)(1) which requires that a design certification application contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the design certification is built and will operate in accordance with the design certification, the provisions of the Atomic Energy Act, and NRC regulations.

3.5.1.1.4 Technical Evaluation

The staff reviewed the U.S. EPR design for protecting SSCs important to safety against internally generated missiles (outside containment) in accordance with the guidance of SRP Section 3.5.1.1. The staff reviewed FSAR Tier 2, Section 3.5.1.1. The staff also reviewed FSAR Tier 1, Section 2.0, "System Based Design Description of ITAAC," and other FSAR Tier 2 sections noted below.

Compliance with GDC 4 is based on meeting the guidance of the following RGs:

- RG 1.115, Revision 1, Regulatory Positions C.1 and C.3, as they relate to the protection of the SSCs important to safety from the effects of turbine missiles.

- Regulatory Position C.1 specifies that essential systems of a nuclear power plant should be protected against low-trajectory turbine missiles due to failure of main turbine-generator sets. Consideration may be limited to the structures, systems, and components listed in the Appendix to RG 1.117, "Tornado Design Classification." The effect of physical separation of redundant or alternative systems may also be considered. Each essential system and its location should be identified on dimensioned plan and elevation layout drawings.

- Regulatory Position C.3 specifies that when protection of essential systems is provided by barriers, dimensioned plan and elevation layout drawings should include information on wall or slab thicknesses and materials of pertinent structures.

- RG 1.117, Revision 1, Appendix A, as to which SSCs should be protected from missile impacts.

FSAR Tier 2, Section 3.5, “Missile Protection,” in part, addresses SSCs important to safety to be protected from internally generated missiles inside and outside containment. FSAR Tier 2, Table 3.2.2-1 lists all the SSCs (safety-related and non-safety-related) in various locations of the plant (inside and outside the containment) and identifies for each SSC the associated seismic category, quality group, and equipment classifications. FSAR Tier 2, Section 7.4, “Systems Required For Safe-shutdown,” lists the safe-shutdown. General arrangement drawings defining the building locations are provided in FSAR Tier 2, Section 1.2, “General Plant Description.”

In FSAR Tier 2, Section 3.5.1.1, the applicant evaluated the potential of internally generated missiles that could result from failure of the plant equipment located outside the containment. The applicant stated that:

1. The potential missiles internally generated outside containment are:

    - missiles resulting from in-plant rotating equipment overspeed failures.

    - missiles resulting from in-plant high-pressure system ruptures such as valves, piping, fittings, tank manways and hand holes, bolts in high energy systems, valve bonnets, valve stems, pressure vessel, thermowells, and retaining bolts.

    - missiles generated by onsite explosions of stored gases. Equipment that uses or generates hydrogen gas is also a potential source of internally generated missiles outside containment.

    - missiles resulting from turbine overspeed failures.

2. Once a potential missile is identified, its statistical significance is determined by the combined probability of an event that is defined as the product of:

- o the probability of missile occurrence
- o the probability of impact on a significant target
- o the probability of significant damage

3. If the combined probability associated with a potential missile is greater than $1x10^{-7}$ per year, the missile is considered as credible and protection of safety-related SSCs against the credible missile will be provided. If the combined probability associated with a potential missile is less than $1x10^{-7}$ per year, the event is considered not statistically significant, the missile is considered as non-credible, and protection of safety-related SSCs against the non-credible missile would not be provided.

In FSAR Tier 2, Section 3.5.1.1.1, "Credible Internally Generated Missiles Sources Outside Containment," the applicant determined the following internally generated missiles outside the containment to be credible:

- missiles generated due to equipment failure resulting from rotating components operating at a 120 percent overspeed condition
- missiles generated from pressurized components such as valves, piping, fittings, tank manways, and bolts in high energy systems with a maximum operating temperature of greater than 93.3 °C (200 °F) or maximum operating pressure of greater than 1.9 MPa (275 psig)
- missiles generated by onsite explosions of stored gases, including equipment that uses or generates hydrogen gas
- internally generated missiles resulting from turbine overspeed failures (addressed in Section 3.5.1.3, "Turbine Missiles") of this report

The applicant stated that the above internally generated credible missiles from sources outside containment were not postulated to occur simultaneously with other plant accidents. However, postulated missile impacts were assumed to occur in conjunction with a single active failure of the SSCs used to attain safe-shutdown of the plant.

In FSAR Tier 2, Section 3.5.1.1.2, "Non-Credible Internally Generated Missile Sources Outside Containment," the applicant determined the following internally generated missiles outside the containment to be non-credible:

- Rotating parts in safety- and non-safety-related equipment located outside containment are designed to have insufficient energy to generate a missile that can pass through their housings.
- Fluid systems other than high energy systems have insufficient stored energy to generate a credible missile.
- Pressure-seal, bonnet-type valves with bonnets designed in accordance with the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) Code, Section III, are non-credible missiles. The ASME Code requires such valves to include retaining rings, which prevent valve bonnets from becoming missiles.

- Valves with bolted bonnets designed in accordance with the ASME B&PV Code, Section III are non-credible missiles. Bolted bonnets are prevented from becoming missiles by limiting the stresses in the bonnet-to-body bolting material.

- Valve stems in high energy systems do not generate credible missiles because, in addition to valve stem threads, either back seats or actuators restrain the stem.

- Valve systems in rotary-motion valves, ball valves (except single-seat ball valves), butterfly valves, and diaphragm-type valves which do not have a large reservoir of pressurized fluid acting on the valve stem have insufficient stored energy to generate a credible missile.

- Nuts, bolts, nut-and-bolt combinations, and nut-and-stud combinations have insufficient stored energy to generate a credible missile.

- Thermowells and similar welded fittings are non-credible missiles because their weld strength exceeds the strength of the parent material.

- Instrumentation and associated piping and tubing contain insufficient high energy fluid to generate a credible missile.

- Ruptures of ASME B&PV Code, Section III pressure vessels, and ruptures of gas storage vessels constructed without welding in accordance with ASME B&PV Code, Section VIII criteria are non-credible based on the conservative design, quality control, and inspection requirements during fabrication.

- Rotating components that operate less than two percent of the system operation time, such as valve actuators are non-credible sources for missiles.

- Components or portions of components that are non-credible missile sources are also non-credible sources of missiles when struck by a falling object.

The applicant stated that once a potential credible missile is identified, protection of safety-related SSCs against the credible missile will be provided in accordance with the guidance of SRP Section 3.5.1.1 by one or more of the following methods:

- locating the system or component in a missile-proof structure

- separating redundant systems or components of the system from the missile path or range

- providing local shields or barriers for systems and components

- designing the equipment to withstand the impact of the most damaging missile

- providing design features to prevent the generation of missile

- orientating a missile source to prevent missiles from striking equipment important to safety

The applicant further stated that the effects of potential internally generated missiles are also minimized by the separation and the redundancy of safety-related systems throughout the U.S. EPR plant. Components within one division of a system with redundant divisions would not be protected from missiles originating from the same division.

In reviewing FSAR Tier 2, Section 3.5.1.1, regarding protection for safety-related SSCs against internally generated missiles outside containment, the staff identified areas in which additional information was necessary to complete its review. Therefore, the staff's RAIs, the applicant's responses, and the staff's evaluation of the applicant's responses are described below:

In RAI 109, Question 03.05.01.01-1a, the staff requested that the applicant provide an assessment of potential gravitational missiles generated outside containment; discuss the measures provided to prevent the impact of a falling object on safety-related SSCs; and revise the FSAR Tier 2, Table 1.8-2, "U.S. EPR Combined License Information Items," to include a COL information item to establish/provide FSAR procedures that provide that equipment, such as a hoist that is used during maintenance, be either removed or seismically restrained following maintenance to prevent it from becoming a missile.

In a February 13, 2009, response to RAI 109, Question 03.05.01.01-1a, the applicant clarified and stated that gravitational missiles are evaluated in FSAR Tier 2, Section 3.7.3.8.1, "Isolation of Seismic and non-Seismic Systems," which requires such items to be shown as acceptable by either separation distance, by a barrier, or classified as Seismic Category II. The applicant further proposed to add a COL information item to FSAR Tier 2, Section 3.5.1.1.3, "Missile Prevention and Protection Outside Containment," to require that a COL applicant that references the U.S. EPR design certification address plant procedures that specify equipment used for maintenance or undergoing maintenance will be either removed or seismically restrained when not in use to prevent it from becoming a missile. In addition, COL Information Item 3.5-1 listed in FSAR Tier 2, Table 1.8-2 will be revised to include controls for unsecured maintenance equipment in safety-related building areas. The staff finds the addition of a COL information item to add controls on maintenance equipment acceptable, because such controls will minimize gravitational missiles which would be generated from equipment used for maintenance.

The staff has confirmed that FSAR Tier 2, Revision 1 of the U.S. EPR FSAR, dated May 29, 2009, was revised to add a new COL Information Item 3.5-9, instead of revising the COL Information Item 3.5-1, to require a COL applicant that references the U.S. EPR design certification to describe controls to confirm that unsecured maintenance equipment, including that required for maintenance and that are undergoing maintenance, will be either removed or seismically supported when not in use to prevent it from becoming a missile, as committed in the RAI response. Accordingly, the staff finds the applicant has adequately addressed this issue and, therefore, the staff considers RAI 109, Question 03.05.01.01-1a resolved.

In RAI 109, Question 03.05.01.01-1b, the staff requested that the applicant clarify an FSAR discrepancy regarding valve bonnet connection types allowed in high energy systems, as described below. In FSAR Tier 2, Table 3.2.2-1, the applicant shows Class 2 and 3 components located in high energy applications. To ensure that the U.S. EPR design minimizes potential missile generation, in FSAR Tier 2, Section 3.5.1.1.3, the applicant states that high energy fluid systems and components are designed according to the requirements of the ASME B&PV Code, Section III or VIII. ASME B&PV Code, Section III requires that valves with removable bonnets be the pressure seal-type or have bolted bonnets; therefore, valves that only have threaded connections between the body and bonnet are not used in high energy systems. The above statement is valid for Section III, Division 1, Class 1 components; however, Section III, Division 1, Class 2 components allow threaded bonnets on pressure relief valves with inlet connections nominal pipe size (NPS) 50.8 mm (2 in.) and less (Section NC-3595.4 and ND-3595.4).

In a December 15, 2008, response to RAI 109, Question 03.05.01.01-1b, the applicant clarified their use of ASME Section III Class 1, 2, and 3 valves and relief valves in high energy systems. All valves in high energy systems designed to ASME Section III Class 1, 2, and 3 will have pressure sealed or bolted bonnets, except for Class 2 and 3 pressure relief valves that are 50.8 mm (2 in.) and smaller. Relief valves with an inlet piping connection 50.8 mm (2 in.) and smaller may have threaded body-to-bonnet connections in accordance with ASME Section III, Division 1, Sections NC-3595.4 and ND-3595.4. The applicant also revised FSAR Tier 2, Section 3.5.1.1.3 to include this clarification. The staff finds the applicant's clarification to the above cited FSAR discrepancy acceptable because valves and pressure relief valves in high energy systems are designed to comply with ASME Section III Code. Therefore, the staff considers its concern as described in RAI 109, Question 03.05.01.01-1b resolved. The staff has confirmed that FSAR Tier 2, Revision 1, dated May 29, 2009, was revised as committed in the RAI response. Accordingly, the staff finds that the applicant has adequately addressed this issue and, therefore, the staff considers RAI 109, Question 03.05.01.01-1b resolved.

In RAI 109, Question 03.05.01.01-1c, the staff requested that the applicant provide an assessment of potential missiles generated outside containment resulting from unsecured and non-seismically restrained compressed gas cylinders during a seismic event; to discuss the measures provided to prevent the impact of such missiles on safety-related SSCs; and to revise FSAR Tier 2, Table 1.8.2 to include a COL information item to establish/provide FSAR procedures which provide that pressurized gas cylinders be either removed or seismically restrained during power operation to prevent them from becoming missiles.

In a February 13, 2009, response to RAI 109, Question 03.05.01.01-1c, the applicant stated that COL Information Item 3.5-1 listed in FSAR Tier 2, Table 1.8-2 will be revised to include the controls to confirm that compressed gas cylinders are removed or seismically restrained when not in use to prevent them from becoming missiles. The staff finds the applicant's proposed revision of COL Information Item 3.5-1 to implement these controls acceptable because potential missiles generated outside containment resulting from unsecured and non-seismically restrained compressed gas cylinders during a seismic event will be minimized.

The staff has confirmed that FSAR Tier 2, Revision 1 of the U.S. EPR FSAR, dated May 29, 2009, was revised to add a new COL Information Item 3.5-8 that requires a COL applicant that references the U.S. EPR design certification to address controls to confirm that unsecured compressed gas cylinders will be either removed or seismically supported when not in use to prevent them from becoming missiles, as committed in the RAI response. Accordingly, the staff finds that the applicant has adequately addressed this issue and, therefore, the staff considers RAI 109, Question 03.05.01.01-1c resolved.

In RAI 109, Question 03.05.01.01-1d, the staff requested that the applicant provide a discussion of whether a postulated guillotine break of a high-energy line outside containment could become a potential missile source, and to discuss the measures provided to prevent the impact of such missiles on safety-related SSCs.

In a December 15, 2008, response to RAI 109, Question 03.05.01.01-1d, the applicant stated that missiles generated from high energy line breaks (HELB) have not been specifically addressed in FSAR Tier 2, Section 3.5.1, “Missile Selection and Description.” However, FSAR Tier 2, Sections 3.5.1.1 and 3.5.1.2, “Internally Generated Missiles (Inside Containment),” refer to FSAR Tier 2, Section 3.6, “Protection Against Dynamic Effects Associated with Postulated Rupture of Piping.” FSAR Tier 2, Section 3.6.1, in part, discusses protection against dynamic effects of HELB. The staff finds the applicant’s response acceptable, because it clarified that missiles generated by HELBs are evaluated under FSAR Tier 2, Section 3.6. The staff’s evaluation of this topic is set forth in Section 3.6 of this report. Therefore, the staff considers its concern as described in RAI 109, Question 03.05.01.01-1d resolved.

In RAI 109, Question 03.05.01.01-1e, the staff requested that the applicant discuss the impact of missile generation resulting from hydrogen piping failures in areas where the piping is routed. In addition, the applicant was requested to provide an evaluation that verifies that no stagnant air pockets exist in areas that have hydrogen piping.

In a February 13, 2009, response to RAI 109, Question 03.05.01.01-1e, the applicant stated that the Fuel Building is the only building that contains both hydrogen gas piping and essential SSCs. The applicant further stated that hydrogen piping is routed in rooms separate from essential SSCs as indicated in FSAR Tier 2, Section 3.5.1.1.3; therefore, no evaluation of stagnant air pockets is required. The staff finds the applicant’s response acceptable, since hydrogen piping is routed in rooms that do not contain essential SSCs. Therefore, the staff considers its concern as described in RAI 109, Question 03.05.01.01-1e resolved.

In RAI 109, Question 03.05.01.01-1f, the staff requested that the applicant provide the drawings as specified by RG 1.115, Position C.3.

In a December 15, 2008, response to RAI 109, Question 03.05.01.01-1f, the applicant stated that the specified drawings are provided in the FSAR Tier 2, Appendix 3B, “Figures,” and the materials are found in FSAR Tier 2, Section 3.8, “Design of Category I Structures.” The staff finds the applicant’s response is acceptable, because the applicant clarified that the information specified in RG 1.115, Position C.3 is provided in the FSAR. Therefore, the staff considers its concern as described in RAI 109, Question 03.05.01.01-1f resolved.

In RAI 109, Question 03.05.01.01-1g, the staff requested that the applicant provide an ITAAC that would require a licensee to perform a walk-down to ensure that SSCs are protected from internally generated missiles (outside containment) in accordance with the description in FSAR Tier 2, Section 3.5.1.1. Also, the staff requested the applicant to identify which of the SSCs are outside and which of the SSCs are inside the containment and to include this information in the FSAR.

In a February 13, 2009, response to RAI 109, Question 03.05.01.01-1g, the applicant stated that FSAR Tier 1, Section 2.1.1, “Nuclear Island,” will be revised to include a description of the loads due to design-basis internal events, including internally generated missiles for the NI structures as well as Section 2.1.2, “Emergency Power Generating Buildings,” and FSAR Tier 2, Section 2.1.5, “Essential Service Water Building,” for the EPGBs and ESWB, respectively. The applicant further stated that FSAR Tier 2, Table 3.2.2-1 lists the SSCs requiring missile protection and their locations (inside or outside of containment), and the ITAAC will verify that SSCs are protected from internal missiles. Based on its review, the staff finds the applicant’s response acceptable because Table 3.2.2-1 lists the SSCs needing missile protection and their locations (outside and inside the containment), and ITAAC will verify that these SSCs have been provided with appropriate protection. In addition, the staff has confirmed that FSAR Tier 1 and Tier 2, Revision 1, dated May 29, 2009, was revised as committed in the RAI response. Accordingly, the staff finds that the applicant has adequately addressed this issue and, therefore, the staff considers RAI 109, Question 03.05.01.01-1g resolved.

Based on the review described above, the staff finds the applicant's approach to identify potential missiles, determine the statistical significance of potential missiles, and provide measures for SSCs needing protection against the effects of missiles to be acceptable. Also, in FSAR Tier 2, Table 3.2.2-1, the applicant lists SSCs that need missile protection. In FSAR Tier 2, Section 7.4, the applicant lists the safe-shutdown systems. The staff finds that the scope of the SSCs afforded missile protection conforms to the guidance of RG 1.115, Positions C.1 and C.3, and RG 1.117, Appendix A. Therefore, the staff concludes that the applicant's evaluation of potential internally generated missiles outside the U.S. EPR containment resulting from equipment and component failures satisfies GDC 4.

Section 3.5.1.3, "Turbine Missiles," of this report addresses the staff's evaluation of protection of safety-related SSCs and stored fuel from the effects of turbine missiles including compliance with the guidance of RG 1.115.

Section 3.5.3, "Barrier Design Procedures," of this report addresses the staff's evaluation of the design of structures, shields, and barriers used for missile protection.

Section 3.6.1 of this report addresses the staff's evaluation of the design of structures, shields, and barriers used for missile protection against dynamic effects of HELB.

Section 3.7.3, "Seismic Subsystem Analysis," of this report addresses the staff's evaluation of the impact of the fall or overturning of non-seismic components on safety-related SSCs resulting from a seismic event.

Section 13.5, "Plant Procedures," of this report addresses the staff's evaluation of plant procedures, including procedures to remove or seismically restrain equipment, such as a hoist that is used during maintenance, when not in use to prevent it from becoming a missile.

ITAAC

As stated in the section above, in a February 13, 2009, response to RAI 109, Question 03.05.01.01-1g, the applicant proposed to revise FSAR Tier 1, Section 2.1.1 to include a description of the loads due to design-basis internal events, including internally generated missiles for the NI structures, as well as for the EPGB and ESWB. FSAR Tier 2, Table 3.2.2-1 lists the SSCs requiring missile protection and their location.

The ITAAC items described in FSAR Tier 1, Section 2.0 for the NI, EPGB, and ESWB verify that the safety-related SSCs are protected from internally generated missiles and the structures have been constructed in accordance with the design as described in FSAR Tier 2. The staff finds that the ITAAC are sufficient to provide reasonable assurance that safety related SSCs will be protected from internally generated missiles outside containment. Therefore, the staff concludes that the missile protection provided for U.S. EPR SSCs located outside containment complies with the requirements of 10 CFR 52.47(b)(1).

3.5.1.1.5 Combined License Information Items

Table 3.5.1.1-1 of this report provides a list of missiles protection related COL Information Item numbers and descriptions from FSAR Tier 2, Table 1.8-2:

Table 3.5.1.1-1 U.S. EPR Combined License Information Items

Item No.	Description	FSAR Tier 2 Section
3.5-8	A COL applicant that references the U.S. EPR design certification will describe controls to confirm that unsecured compressed gas cylinders will be either removed or seismically supported when not in use to prevent them from becoming missiles.	3.5.1.1.3
3.5-9	A COL applicant that references the U.S. EPR design certification will describe controls to confirm that unsecured maintenance equipment, including that required for maintenance and that are undergoing maintenance, will be either removed or seismically supported when not in use to prevent it from becoming a missile.	3.5.1.1.3

The staff finds the above list of COL information items to be complete, and adequately describes the actions necessary for the COL applicant. No additional COL information items need to be included in FSAR Tier 2, Table 1.8-2 for protection from internally generated missiles outside the containment.

3.5.1.1.6 Conclusions

Based on the foregoing, the staff concludes that the applicant's design bases for SSCs important to safety necessary to maintain a safe plant shutdown, ensure the integrity of the reactor coolant pressure boundary (RCPB), and prevent a significant uncontrolled release of radioactivity meet the 10 CFR Part 50, Appendix A, GDC 4 requirements for SSCs to be protected from internally-generated missiles (outside containment), because the applicant has:

- conformed with the guidance recommended in: RG 1.115, Sections C.1 and C.3, as to the identification and protection of SSCs important to safety from the effects of turbine missiles, respectively; and RG 1.117 as to which SSCs should be protected from missile impacts

- complied with the guidance of Section 3.5.1.1 of the SRP to identify potential sources of internal missiles

- demonstrated that the functions of SSCs important to safety will be protected from internally-generated missiles (outside containment) by individual missile-proof structures, adequate physical separation for redundant systems or the components of systems, or special localized protective shields or barriers for the systems or components

3.5.1.2 *Internally Generated Missiles Inside Containment*

3.5.1.2.1 Introduction

All SSCs important to safety located inside containment are to be protected from internally-generated missiles to ensure compliance with GDC 4 requirements. This includes all SSCs within the containment and the containment itself. It includes internally-generated missiles from component overspeed failures, missiles that could originate from high-energy fluid system failures, and missiles caused by or as a consequence of gravitational effects. An internally-generated missile has a dynamic effect and its impact on SSCs important to safety must be evaluated to ensure that they are protected adequately and will be capable of performing their safety functions. If a missile has a statistically significant probability of causing damage, it is considered credible. Protecting SSCs located inside containment from the effects of internally generated missiles ensures the integrity of the RCPB, the capability to shut down and maintain the reactor in a shutdown condition, and the capability to prevent a significant uncontrolled release of radioactivity.

3.5.1.2.2 Summary of Application

FSAR Tier 1: There is no FSAR Tier 1 information directly related to internally generated missiles or missile protection for SSCs located inside containment. FSAR Tier 1, Section 2.1.1 describes the design of the NI structures including but not limited to the RB, SB, and FB.

FSAR Tier 2: FSAR Tier 2, Section 3.5.1.2 describes the internally generated missile sources and missile protection for SSCs located inside containment. The basis for identifying credible and not credible missiles is presented along with the design measure to limit missile generation and provide protection to SSCs inside containment.

ITAAC: FSAR Tier 1, Table 2.1.1-4 provides ITAAC requirements for the NI structures. FSAR Tier 2, Section 14.3 does not provide any ITAAC requirements related to missile generation or protection. FSAR Tier 2, Section 14.2 does not provide any initial testing requirements associated with this area of review.

3.5.1.2.3 Regulatory Basis

The relevant requirements of NRC regulations for this area of review, and the associated acceptance criteria, are given in NUREG-0800, Section 3.5.1.2. Review interfaces with other SRP sections also can be found in NUREG-0800, Section 3.5.1.2.I.

1. GDC 4, as it relates to the design of the SSCs important to safety to protect them from internally generated missiles inside containment, requires, in part, that SSCs important to safety shall be appropriately protected against the dynamic effects of internally generated missiles inside containment that may result from equipment failures.

2. 10 CFR 52.47(b)(1) which requires that a design certification application contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the design certification is built and will operate in accordance with the design certification, the provisions of the Atomic Energy Act, and NRC regulations.

3.5.1.2.4 Technical Evaluation

The staff reviewed the U.S. EPR design for protecting SSCs important to safety against internally generated missiles (inside containment) in accordance with the guidance of SRP Section 3.5.1.2. The staff reviewed FSAR Tier 2, Section 3.5.1.2. The staff also reviewed FSAR Tier 1, Section 2.0 and other FSAR Tier 2 sections noted below.

FSAR Tier 2, Section 3.5, "Missile Protection," in part, addresses SSCs important to safety to be protected from internally generated missiles inside and outside containment. FSAR Tier 2, Table 3.2.2-1, "Classification Summary," lists all the SSCs (safety-related and non-safety-related) in various locations of the plant (inside and outside the containment) and identifies for each SSC the associated seismic category, quality group and equipment classifications. FSAR Tier 2, Section 7.4 lists the safe-shutdown. General arrangement drawings defining the building locations are provided in FSAR Tier 2, Section 1.2, "General Plant Description."

In FSAR Tier 2, Section 3.5.1.2, the applicant evaluated the potential for internally generated missiles that could result from failure of the plant equipment located inside the containment. The applicant stated that:

1. The potential sources of internally generated missiles inside containment are:

    - missiles resulting from rotating equipment overspeed failures

    - missiles resulting from high-pressure system ruptures such as valves, piping, fittings, tank manways; hand holes, bolts in high energy systems, valve bonnets, valve stems, pressure vessel, thermowells, retaining bolts; and high pressure gas storage cylinders

    - gravitational missiles resulting from falling maintenance equipment that is used during maintenance and is not either removed during operation to a location where it is not a potential hazard to safety-related equipment or seismically restrained to prevent it from becoming a missile

3. Once a potential missile is identified, its statistical significance is determined, following the guidance described in SRP Section 3.5.1.2, by the combined probability of an event that is defined as the product of all of the following:

    - the probability of missile occurrence

    - the probability of impact on a significant target

    - the probability of significant damage

4. If the combined probability associated with a potential missile is greater than $1x10^{-7}$ per year, the missile is considered as credible, and protection of safety-related SSCs against the credible missile will be provided. If the combined probability associated with a potential missile is less than $1x10^{-7}$ per year, the event is considered not statistically significant, the missile is considered as in applicant stated that the credible, and protection of safety-related SSCs against the non-credible missile would not be provided.

In FSAR Tier 2, Section 3.5.1.2.1, the applicant determined the following internally generated missiles inside the containment to be credible:

- missiles generated due to equipment failure resulting from rotating components operating at a 120 percent overspeed condition
- missiles generated from pressurized components such as valves, piping, fittings, tank manways, and bolts in high energy systems with a maximum operating temperature of greater than 93.3 °C (200 °F) or maximum operating pressure of greater than 1.9 MPa (275 psig)
- missiles generated from equipment inside containment that uses or generates hydrogen gas

The applicant stated that the above internally generated credible missiles from sources inside containment are similar to those internally generated credible missiles outside containment identified in FSAR Tier 2, Section 3.5.1.1. These internally generated credible missiles from sources inside containment are also not postulated to occur simultaneously with other plant accidents. However, postulated missile impacts are assumed to occur in conjunction with a single active failures of the SSCs used to attain safe-shutdown of the plant.

In FSAR Tier 2, Section 3.5.1.2.2, "Non-Credible Internally Generated Missile Sources Inside Containment," the applicant determined the following internally generated missiles inside the containment to be non-credible:

- Rotating parts from the reactor coolant pumps (RCPs) are non-credible missiles, since the pumps are designed in conformance with RG 1.14, "Reactor Coolant Pump Flywheel Integrity," which provides reasonable assurance that there will be an extremely low probability of flywheel-generated missiles.
- Rotating components in equipment located inside containment are designed to have insufficient energy to generate a missile that can pass through their housings.
- Pressure vessels inside containment designed to ASME B&PV, Section III are non-credible missile sources based on the conservative design, quality control, and inspection requirements during fabrication, erection and operation.
- Pressure-seal, bonnet-type valves with bonnets designed in accordance with the ASME B&PV Code, Section III, are non-credible missiles. The ASME Code requires such valves to include retaining rings which prevent valve bonnets from becoming missiles.
- Valves with bolted bonnets designed in accordance with the ASME B&PV Code, Section III are non-credible missiles. Bolted bonnets are prevented from becoming missiles by limiting the stresses in the bonnet-to-body bolting material.
- Valve stems in high energy systems do not generate credible missiles because, in addition to valve stem threads, either back seats or actuators restrain the stems.
- Valve systems in rotary-motion valves, ball valves (except single-seat ball valves), butterfly valves, and diaphragm-type valves do not have a large reservoir of pressurized

fluid acting on the valve stem and have insufficient stored energy to generate a credible missile.

- Nuts, bolts, nut-and-bolt combinations, and nut-and-stud combinations have insufficient stored energy to generate a credible missile.
- Thermowells and similar welded fittings are non-credible missiles because their weld strength exceeds the strength of the parent material.
- Fluid systems other than high energy systems have insufficient stored energy to generate a credible missile.
- A control rod drive mechanism (CRDM) housing failure sufficient to create a missile from a piece of the housing or to allow a control rod to be ejected rapidly from the core, is non-credible, based on design, examination, test and inspection requirements to ASME B&PV Code, Section III, Class 1 components.
- Hydrogen is supplied to the reactor coolant system (RCS) by the chemical and volume control system. There is no hydrogen gas inside containment to generate a missile.
- The Reactor Containment Building (RCB) is a Seismic Category I concrete structure with a 6.4 mm (0.25 in.) steel liner. The steel liner prevents the generation of secondary missiles (concrete fragments) resulting from the impact of primary missiles.

The applicant stated that:

1. Once a potential credible missile is identified, protection of safety-related SSCs against the credible missile will be provided by one or more of the following methods:
    - separating redundant systems or components from the missile path or range
    - providing missile barriers between redundant divisions of equipment that are housed adjacent to one another
    - providing local shields and barriers for systems and components
    - designing the equipment to withstand the impact of the most damaging missile
    - providing design features to prevent missile generation
    - orienting missile source to prevent missiles from striking equipment important to safety
2. The plant design is such that a RCS generated missile does not cause a loss of integrity of the primary containment, main steam, feedwater, or any other loop of the RCS. A postulated missile from any other system will not cause a loss of integrity of the primary containment or RCS pressure boundary.
3. The effects of potential internally generated missiles are minimized by separation and redundancy of safety-related systems throughout the containment. Components within one division of a system with redundant divisions would not be protected from missiles originating from the same division.

In FSAR Tier 2, Section 3.7.3.8, "Interaction of Other Systems with Seismic Category I Systems," the applicant addressed the evaluation of any safety-related SSC that may be impacted by a non-seismically restrained component to establish that there is no loss of its safety-related function. In addition, in FSAR Tier 2, Section 3.5.1.2.3, "Missile Prevention and Protection Inside Containment," the applicant stated that a combined license applicant that references the U.S. EPR design certification will describe controls to confirm that unsecured maintenance equipment, including that required for maintenance and that are undergoing maintenance, will be removed from containment prior to operation, moved to a location where it is not a potential hazard to SSCs important to safety, or seismically restrained to prevent it from becoming a missile. (This is COL Information Item 3.5-1.)

In reviewing FSAR Tier 2, Section 3.5.1.2, regarding protection for safety-related SSCs located inside containment from internally generated missiles, the staff identified areas in which additional information was necessary to complete its review. Therefore, the staff issued to the applicant the RAIs discussed below. The staff's RAIs, the applicant's responses, and the staff's evaluation of the applicant's responses are described below:

In the event of a CRDM nozzle flange or pressure housing failure, the closure head equipment retains the CRDMs so that they are prevented from becoming a missile source. FSAR Tier 2, Section 3.5.1.2.3 states the SSCs inside containment are designed to withstand a postulated CRDM missile, even though this event is deemed not credible. In RAI 109, Question 03.05.01.02-1a, the staff requested that the applicant clarify if the inside containment SSCs are capable of withstanding a CRDM missile impact.

In a December 15, 2008, response to RAI 109, Question 03.05.01.02-1a, the applicant clarified that the U.S. EPR design provides a concrete missile shield over the refueling canal to absorb impact of control rod ejection due to postulated failure of a CRDM. The missile shield provides a barrier between CRDM and other inside containment SSCs such that SSCs beyond the missile shield need not be designed to withstand a CRDM missile impact. The applicant stated that FSAR Tier 2, Section 3.5.1.2.3 will be revised to reflect the design. The staff has confirmed that FSAR Tier 2, Revision 1, dated May 29, 2009, was revised as committed in the RAI response. Accordingly, the staff finds that the applicant has adequately addressed this issue and, therefore, the staff considers RAI 109, Question 03.05.01.02-1a resolved.

Section 3.5.3 of this report addresses the staff's evaluation of the design of structures, shields, and barriers used for missile protection.

FSAR Tier 2, Section 3.5.1.2 describes the applicant's approach to identify potential missiles, determine the statistical significance of potential missiles and provide measures for SSCs requiring protection against the effects of missiles inside containment. However, FSAR Tier 1, Section 2.0 does not contain design commitments or ITAAC to verify that SSCs inside containment are designed and constructed in accordance with the description in FSAR Tier 2, Section 3.5.1.2 to prevent or mitigate the effects of internally generated missiles inside containment.

Therefore, in RAI 109, Question 03.05.01.02-2b, the staff requested that the applicant provide an ITAAC that would require a licensee to perform a walk-down of the SSCs and to ensure that SSCs are protected from internally generated missiles (inside containment) in accordance with the description in FSAR Tier 2, Section 3.5.1.2. This RAI was identical to the RAI (RAI 109, Question 03.05.01.01-1g) which was issued to the applicant during the staff's review of FSAR Tier 2, Revision 0, Section 3.5.1.1.

In a February 13, 2009, response to RAI 109, Question 03.05.01.01-1g, the applicant stated that FSAR Tier 1, Section 2.1.1 will be revised to include a description of the loads due to design-basis internal events, including internally generated missiles for the NI structures as well as FSAR Tier 1, Section 2.1.2 and FSAR Tier 1, Section 2.1.5 for the EPGB and ESWB, respectively. FSAR Tier 2, Table 3.2.2-1 lists the SSCs requiring missile protection and their locations. The applicant further stated that since the description of design-basis loads now includes internally generated missiles the ITAAC will verify that SSCs are protected from internal missiles. Since missile loads will be accounted for in the design, and construction will be verified by the ITAAC, the staff finds the applicant's response for RAI 109, Questions 03.05.01.01-1g and 03.05.01.02-2b acceptable. Therefore, the staff considers its concern as described in RAI 109, Question 03.05.01.02-1b resolved. The staff has confirmed that FSAR Tier 1, Revision 1, dated May 29, 2009, was revised as committed in the RAI response. Accordingly, the staff finds that the applicant has adequately addressed this issue and, therefore, the staff considers RAI 109, Question 03.05.01.02-1b resolved.

Based on the review described above, the staff finds the applicant's approach to identify potential missiles, determine the statistical significance of potential missiles, and provide measures for SSCs requiring protection against the effects of missiles to be acceptable. Therefore, the staff concludes that the applicant's evaluation of potential internally generated missiles inside the U.S. EPR containment resulting from equipment and component failures satisfies GDC 4.

Section 3.6.2 of this report addresses the staff's evaluation of the dynamic effects associated with the postulated rupture of piping inside the containment.

Section 3.7.3 of this report addresses the staff's evaluation of the impact of the fall or overturn of non-seismic components on safety-related SSCs as a result of a seismic event.

Section 13.5 of this report addresses the staff's evaluation of plant procedures, including procedures to remove or seismically restrain equipment, such as a hoist that is used during maintenance, when not in use to prevent it from becoming a missile.

ITAAC

As stated in the above section, in its response to RAI 109, Question 03.05.01.02-1b, the applicant proposed to revise FSAR Tier 1, Section 2.1.1 to include a description of the loads due to design-basis internal events, including internally generated missiles for the NI structures. FSAR Tier 2, Table 3.2.2-1 lists the SSCs requiring missile protection and their location.

The ITAAC items described in FSAR Tier 1, Section 2.0 for the NI verify that the safety-related SSCs are protected from internally generated missiles and are designed and perform as described in FSAR Tier 2. Therefore, the staff concludes that the missile protection provided for U.S. EPR SSCs located inside containment complies with the requirements of 10 CFR 52.47(b)(1).

3.5.1.2.5 Combined License Information Items

Table 3.5.1.2-1 of this report provides a list of missiles protection related COL information item numbers and descriptions from FSAR Tier 2, Table 1.8-2:

Table 3.5.1.2-1 U.S. EPR Combined License Information Items

Item No.	Description	FSAR Tier 2 Section
3.5-1	A COL applicant that references the U.S. EPR design certification will describe controls to confirm that unsecured maintenance equipment, including that required for maintenance and that are undergoing maintenance, will be removed from containment prior to operation, moved to a location where it is not a potential hazard to SSCs important to safety, or seismically restrained to prevent it from becoming a missile.	3.5.1.2.3

The staff finds the above list of COL information items to be complete. Also, the listing adequately describes the actions necessary for the COL applicant. No additional COL information items need to be included in FSAR Tier 2, Table 1.8-2 for protection from internally generated missiles inside the containment.

3.5.1.2.6 Conclusions

Based on the foregoing, the staff concludes that the applicant's design bases for SSCs important to safety necessary to maintain a safe plant shutdown, ensure the integrity of the RCPB, and prevent a significant uncontrolled release of radioactivity meet the 10 CFR Part 50, Appendix A, GDC 4 requirements for SSCs to be protected from internally-generated missiles (inside containment).

3.5.1.3 *Turbine Missiles*

3.5.1.3.1 Introduction

NRC regulations require that SSCs important to safety shall be appropriately protected against dynamic effects of postulated accidents, including the effects of missiles, pipe whipping, and discharging fluids that may result from equipment failures and from events and conditions outside the nuclear power unit. One potential source of plant missiles is the rotor of the main turbine. This must be considered in the plant's design, and the adverse effects of postulated turbine missiles must be protected against.

The objective of the staff review is to determine that potential turbine missiles have been appropriately identified and that SSCs important to safety have been appropriately protected from any adverse effects that may result from these missiles.

3.5.1.3.2 Summary of Application

FSAR Tier 1: There are no FSAR Tier 1 entries for this area of review.

FSAR Tier 2: The applicant has provided a FSAR Tier 2 system description in FSAR Tier 2, Section 3.5.1.3, summarized here in part, as follows:

GDC 4 requires that SSCs important to safety shall be appropriately protected against the effects of missiles. One method of protecting SSCs important to safety is to orient the rotational axis of the main turbine rotor such that the trajectory of any postulated turbine missiles will not result in impact of the missile on these SSCs.

This section of the FSAR describes any buildings that could be impacted by a potential turbine missile. Typical turbine missiles may be turbine rotor blades or segments of a turbine disk. The FSAR states that using NRC guidance contained in RG 1.115, four safety-related structures may potentially be impacted by a turbine missile. These structures are: Two of the four ESWBs and a portion of one of the four EPGBs. In accordance with the guidance provided in SRP Section 2.2.3, “Evaluation of Potential Accidents,” and RG 1.115, the probability of unacceptable damage from turbine missiles should be less than or equal to 1 in 10 million per year for an individual plant.

ITAAC: There are no ITAAC items for this area of review. ITAAC Commitment No. 1.0a and No. 1.0b concerning turbine rotor material properties and inspection/testing in accordance with the manufacturer’s turbine missile probability analysis are discussed in Section 10.2.4.2.1 of this report.

3.5.1.3.3 Regulatory Basis

The relevant requirements of NRC regulations for this area of review, and the associated acceptance criteria, are given in NUREG-0800, Section 3.5.1.3 and are summarized below. Review interfaces with other SRP sections also can be found in NUREG-0800, Section 3.5.1.3.

- GDC 4, as it relates to SSCs important to safety being appropriately protected against environmental and dynamic effects, including the effects of missiles that may result from equipment failure.

Acceptance criteria adequate to meet the above requirements include:

- RG 1.115, as it relates to the identification of low-trajectory missiles resulting from turbine failure.

3.5.1.3.4 Technical Evaluation

The failure of a rotor in a large steam turbine may result in the generation of high energy missiles that could affect safety-related SSCs. The probability of a strike by a turbine missile should be sufficiently low so that the risk from turbine missiles on safety-related SSCs is acceptably small. FSAR Tier 2, Section 3.5.1.3 provides information that the probability of the favorably oriented turbine generator generating a turbine missile is less than $1x10^{-4}$. The staff reviewed this information using the guidelines in SRP Section 3.5.1.3.

SRP Section 3.5.1.3 states that with the use of proper turbine rotor design, materials that satisfy the acceptance criteria in SRP Section 10.2.3, “Turbine Rotor Integrity,” and acceptable preservice and inservice nondestructive examination methods, the probability of turbine missile generation, P_1, is expected to be no greater than $1x10^{-5}$ per reactor year for an unfavorably oriented turbine and no greater than $1x10^{-4}$ for a favorably oriented turbine. This probability represents the general minimum reliability for loading the turbine and bringing the system on line.

FSAR Tier 2, Section 3.5.1.3 does not provide a turbine missile analysis for either of the two turbine generator designs specified in FSAR Tier 2, Section 10.2. In a March 31, 2009, response to RAI 91, Question 10.02-1, and as revised in Revision 1 of the FSAR, the applicant stated that the alternate turbine-generator design described in FSAR Tier 2, Section 10.2A is no longer part of the U.S. EPR design. Also, FSAR Tier 2, Section 10.2.3.6, “Turbine Rotor Inservice Inspection Program Plan,” specifies that an ASME Code inspection be performed every 10 years and specifies volumetric inspections. This does not conform with the staff’s guidance in SRP Section 3.5.1.3, which states that applicants with turbines with no NRC approved reports on turbine missile generation probabilities should commit to a program which includes a volumetric inservice inspection with an inspection interval not to exceed 3 years or two fuel cycles. The staff identified in RAI 18, Question 03.05.01.03-1, that, if no turbine missile analysis is performed, then the 3-year inspection interval (for volumetric inspections) should be used. In a July 23, 2008, response to RAI 18, Question 03.05.01.03-1, the applicant stated that the turbine missile probability analysis will be provided by the COL applicant for the turbine generator design selected. In addition, the applicant revised FSAR Tier 2, Table 1.8-2 in Revision 1 to state that the COL applicant will provide the site-specific inservice inspection program consistent with the manufacturer’s turbine missile analysis. Therefore, the staff finds acceptable that the COL applicant will provide the manufacturer’s turbine missile probability analysis and the corresponding inservice turbine rotor inspection program consistent with the manufacturer’s analysis, because it meets the intent of SRP Section 3.5.1.3. Additional information concerning the inservice turbine rotor inspection program is discussed in Section 10.2.3 of this report.

Revision 0 of the FSAR Tier 2, Section 3.5.1.3 stated that all safety-related structures, except for two of the four ESWBs and a portion of one of the four EPGBs, are located outside of the low-trajectory missile strike zone, as defined in RG 1.115. Therefore, the FSAR considered the turbine generator is favorably positioned, because most of the safety-related SSCs are located outside the low-trajectory missile strike zone. In addition, the supporting turbine missile analysis evaluated the probability of a turbine missile being ejected as less than $1x10^{-4}$. In RAI 109, Question 03.05.01.03-2, the staff identified that two of the ESWBs and EPGBs, which are considered safety-related structures and systems, are located in the low-trajectory missile strike zone.

In a February 19, 2009, response to RAI 109, Question 03.05.01.03-2, the applicant stated that the U.S. EPR has four redundant divisions, each of which is capable of bringing the reactor to safe shutdown and maintaining it in safe shutdown condition, as stated in FSAR Tier 2, Section 1.2.3.1.1, “Overview.” In Revision 1 to FSAR 2, Section 3.5.1.3, the applicant clarified that the axis of the turbine rotor shafts is positioned such that safety-related structures, except for two of the four ESWBs and two of the four EPGBs, are located outside the turbine low trajectory hazard zone, as defined by RG 1.115. Therefore, two of the four divisions remain available and each division is capable of performing the necessary safety functions, as stated in FSAR Tier 2, Section 1.2.3.1.1. The staff finds that since two of the four redundant divisions are not in the missile strike zone, and each division can safely shut down the reactor, the turbine generator is considered to be in a favorable position.

The staff examined FSAR Tier 1, Figure 2.1.2-1, “U.S. EPR Building Layout Showing EPGB Locations,” and the information in response to RAI 109, Question 03.05.01.03-2, and the staff finds that this figure shows that the turbine is designed in a favorable orientation with respect to safety-related systems. The favorably oriented turbine will minimize the potential of a turbine missile striking any safety-related systems should the turbine fail. Therefore, the U.S. EPR design satisfies SRP Section 3.5.1.3 guidance in terms of the probability of turbine missile generation and favorably oriented turbine placement.

SRP Section 3.5.1.3.II.4 states that the turbine manufacturers should provide COL applicants with tables of missile generation probabilities versus time (inservice visual, surface, and volumetric rotor inspection interval for design speed failure and inservice valve testing interval for destructive overspeed failure). These probabilities should be used to establish inservice and test schedules that meet NRC safety objectives. This calls for the COL applicant to demonstrate the capability to perform volumetric (ultrasonic) examinations suitable for inservice inspection (ISI) of turbine rotors and shafts and to provide reports describing its methods for determining turbine missile generation probabilities for NRC review and approval.

COL Information Item 3.5-2 in FSAR Tier 2, Table 1.8-2 states that the COL applicant will confirm the evaluation of the probability of turbine missile generation. However, FSAR Tier 2, Section 3.5.1.3, does not provide a turbine missile analysis for the turbine generator design specified in FSAR Tier 2, Section 10.2, and the staff identified this concern in RAI 109, Question 03.05.01.03-3.

In a December 15, 2008, response to RAI 109, Question 03.05.01.03-3, the applicant stated that each specific turbine missile analysis is a function of the selected turbine, and thus is a COL applicant provided analysis. Once a specific turbine design is selected, the COL applicant provides a design-specific turbine missile analysis as required by ITAAC Item 1.0b and COL Information Item 3.5-2. The staff notes that ITAAC Item 1.0b is used for the as-built turbine rotor, and that the COL Information Item 3.5-2 is for the design-specific turbine generator. Accordingly, the COL applicant may provide a bounding turbine missile analysis for the turbine design, using bounding material properties, in lieu of actual material properties. In addition, the staff finds it acceptable that the COL holder will have the as-built turbine missile analysis available after the turbine generator is procured, since the material properties of the as-built rotor will not be available until after fabrication. The COL applicant will use this bounding analysis to evaluate and reconcile that the as-built turbine missile probability, P1, is less than 1×10^{-4}. Therefore, the staff concludes that the probability of turbine missile generation is consistent with the criteria in SRP Section 3.5.1.3 and RG 1.115.

Section 10.2.3 of this report provides additional discussion of the staff's evaluation of the turbine ISI program. Section 10.2.2 of this report discusses the staff's detailed evaluation of the turbine overspeed protection system of the U.S. EPR turbine design. On the basis of the above evaluation, the staff concludes that the probability of turbine missile generation and turbine orientation as described in FSAR Tier 2, Section 3.5.1.3, are consistent with the acceptance criteria in SRP Section 3.5.1.3 and RG 1.115.

3.5.1.3.5 Combined License Information Items

Table 3.5.1.3-1 of this report provides a list of turbine missile related COL Information Item numbers and descriptions from FSAR Tier 2, Table 1.8-2:

Table 3.5.1.3-1 U.S. EPR Combined License Information Items

Item No.	Description	FSAR Tier 2 Section
3.5-2	A COL applicant that references the U.S. EPR design certification will confirm the evaluation of the probability of turbine missile generation for the selected turbine generator, P1, is less than $1x10^{-4}$ for turbine-generators favorably oriented with respect to containment.	3.5.1.3
3.5-3	A COL applicant that references the U.S. EPR design certification will assess the effect of potential turbine missiles from turbine generators within other nearby or co-located facilities.	3.5.1.3

The staff finds the above list of COL information items to be complete, and adequately describes the actions necessary for the COL applicant. No additional COL information items need to be included in FSAR Tier 2, Table 1.8-2 for turbine missiles.

3.5.1.3.6 Conclusions

Based on the foregoing, the staff concludes that the applicant has specified a favorable turbine orientation in the design. This conforms to the guidance in SRP Section 3.5.1.3 and RG 1.115. FSAR Tier 2 also requires that the COL applicant provide an evaluation which concludes that the probability of turbine missile generation (P1) is less than $1x10^{-4}$, which also conforms to the applicable guidance. Therefore, the staff concludes that the risk posed by turbine missiles for the proposed plant design is acceptable and meets the relevant requirements of GDC 4. The staff bases this conclusion on the applicant having sufficiently demonstrated to the staff, in accordance with the guidance of SRP Section 3.5.1.3 and RG 1.115, that the overall probability of turbine missile damage to SSCs important to safety is acceptably low, provided the turbine selected by a COL applicant referencing the U.S. EPR design has a P1 less than $1x10^{-4}$.

The staff will review the plant-specific turbine system maintenance program and the calculation of the plant-specific probability of turbine missile generation when submitted by the COL applicant.

3.5.1.4 *Missiles Generated by Tornadoes and Extreme Winds*

3.5.1.4.1 Introduction

Missiles generated by high-speed winds, such as tornado, hurricane, and any other extreme winds are identified and evaluated in this section. A COL applicant that references the U.S. EPR design certification will assess whether the actual site characteristics fall within the site parameters specified for the U.S. EPR design. If a site characteristic does not fall within the corresponding site parameter, the COL applicant will evaluate the potential for other missiles generated by natural phenomena, such as hurricanes and extreme winds, and their potential impact on the missile protection design features of the U.S. EPR.

3.5.1.4.2 Summary of Application

FSAR Tier 1: FSAR Tier 1, Table 5.0-1, "Site Parameters for the U.S. EPR Design," lists the tornado site parameters. There is no other FSAR Tier 1 information related to missiles generated by tornadoes or extreme winds.

FSAR Tier 2: FSAR Tier 2, Section 3.5.1.4 describes the array of missiles generated by tornadoes and extreme winds as:

- a massive high-kinetic-energy missile that deforms on impact
- a rigid missile that tests penetration resistance
- a small rigid missile of a size that is sufficient to pass through openings in protective barriers

ITAAC: FSAR Tier 1, Tables 2.1.1-4, 2.1.2-3, and 2.1.5-3 provide ITAAC requirements for the NI structures, EPGB, and ESWB, respectively. There are no specific FSAR Tier 1 ITAAC items for this area of review

Initial Plant Test Program: FSAR Tier 2, Section 14.2 does not provide any preoperational testing requirements associated with this area of review.

3.5.1.4.3 Regulatory Basis

The relevant requirements of NRC regulations for this area of review, and the associated acceptance criteria, are given in NUREG-0800, Section 3.5.1.4 and are summarized below. Review interfaces with other SRP sections also can be found in NUREG-0800, Section 3.5.1.4.I.

1. GDC 2 requires, in part, that SSCs important to safety shall be designed to withstand the effects of natural phenomena such as tornadoes and hurricanes without loss of capability to perform their safety functions.

2. GDC 4 requires, in part, that SSCs important to safety shall be appropriately protected against the effects of missiles that may result from events and conditions outside the nuclear power unit.

3. 10 CFR 52.47(b)(1) which requires that a design certification application contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the design certification is built and will operate in accordance with the design certification, the provisions of the Atomic Energy Act, and NRC regulations.

3.5.1.4.4 Technical Evaluation

The staff reviewed the U.S. EPR design for protecting SSCs important to safety against missiles generated by tornadoes and extreme winds in accordance with the guidance of SRP Section 3.5.1.4. The staff reviewed FSAR Tier 2, Section 3.5.1.4. The staff also reviewed FSAR Tier 1, Section 2.0 and other FSAR Tier 2 sections noted below.

Compliance with GDC 2 and GDC 4 with respect to missiles generated by high winds is based on meeting the guidance of the Positions C.1, "Design-Basis Tornado Parameters," and C.2, "Design-Basis Tornado-Generated Missile Spectrum," of RG 1.76, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants."

In FSAR Tier 1, Table 5.0-1, FSAR Tier 2, Table 2.1.1, "U.S. EPR Site Design Envelope," and FSAR Tier 2, Section 3.3.2.1, "Applicable Tornado Design Parameters," the applicant provides the following design basis tornado parameters and tornado-generated missile spectra for the U.S. EPR design:

Design Basis Tornado Parameters

- radius of maximum rotational speed of 45.7 m (150 ft)
- maximum wind speed of 370 km/h (230 mph)
- maximum rotational speed of 296 km/h (184 mph)
- maximum translational speed of 74 km/h (46 mph)
- maximum pressure drop of 8.3 kPa (1.2 psi)
- rate of pressure drop of 3.4 kPa/s (0.5 psi/s)
- exceedance frequency of 1×10^{-7} per year

Tornado-Generated Missile Spectra

- a massive high-kinetic-energy missile that deforms on impact, such as an 1,814 kg (4,000 lb) automobile. Design impact velocity: Horizontal 41 m/s (135 ft/s), Vertical 27.4 m/s (90 ft/s)
- a rigid missile that tests penetration resistance, such as a 152 mm (6 in.) diameter Schedule 40 pipe. Design impact velocity: Horizontal 41 m/s (135 ft/s), Vertical 27.4 m/s (90 ft/s)
- a small rigid missile of a size that is sufficient to pass through openings in protective barriers, such as a 25 mm (1 in.) diameter solid steel sphere. Design impact velocity: Horizontal 7.9 m/s (26 ft/s), Vertical 5.2 m/s (17 ft/s)

In addition, automobile missiles are considered to impact at an altitude of less than 9.1 m (30 ft) above plant grade in accordance with the recommendations of RG 1.76.

The guidance of RG 1.76 only applies to the continental U.S., which is divided into three regions: Region I − the central portion of the U.S.; Region II − a large region of the U.S. along the east coast, the northern border, and western Great Plains; and Region III − the western U.S. The staff finds that the above design-basis tornado parameters and tornado-generated missile spectra are in accordance with the guidance described in RG 1.76, Table 1, for Region I. The tornado parameter values specified in RG 1.76, Table 1 for Region I are most severe and bound all the tornado parameter values specified for Regions II and III. See Section 2.3 of this report for the staff's evaluation of meteorological site parameters. The staff's evaluation of the structural performance of the U.S. EPR with respect to tornado missiles is set forth in Section 3.8 of this report. Based on that evaluation, the staff concludes that the U.S. EPR design meets the requirements of GDC 2 and GDC 4 with respect to protection for safety-related SSCs against the effects of natural phenomena such as tornadoes and hurricanes.

ITAAC

In FSAR Tier 1, Section 2.0, the applicant provides the design descriptions and ITAAC that verify that the following structures to be protected from missiles generated by tornadoes and extreme winds have been constructed in accordance with the design as described in FSAR Tier 2:

Nuclear Island

The NI consists of all of the structures supported by the NI common basemat structures. The NI includes the RBSB, FB, main steam valve (MSV) and main feed valve (MFV) stations.

FSAR Tier 1, Table 2.1.1-4, ITAAC Item 3.7 requires verification by inspection of the NI structures design analyses versus construction records to ensure that the structures are constructed in accordance with the design as described in FSAR Tier 2.

Emergency Power Generating Buildings

The EPGBs are safety-related, Seismic Category I, reinforced-concrete structures supported by a reinforced-concrete basemat. There are two essentially identical EPGBs (EPGB 1/2 and EPGB 3/4) located adjacent to the NI.

FSAR Tier 1, Table 2.1.2-3, ITAAC Items 3.3 and 3.4 require verification that the EPGB structures are Seismic Category I and constructed to withstand design basis loads in accordance with the design as described in FSAR Tier 2 without loss of structural integrity.

Essential Service Water Building

Each of the four ESWBs is an independent, safety-related, Seismic Category I, reinforced-concrete structure. Each ESWB houses an ESWCT structure and an ESWPB. The ESWCT houses two cooling towers and a water storage basin. The ESWPB houses pumps and electrical equipment. A total of four ESWBs are located in pairs on each side of the NI complex.

FSAR Tier 1, Table 2.1.5-3, ITAAC Items 3.2, 3.4, and 3.5 require verification that the ESWB structures are four separate ESWBs and are designed and constructed to withstand design basis loads as specified in FSAR Tier 2 without loss of structural integrity.

The staff finds the above cited ITAAC items acceptable, as they require a licensee to verify that the safety-related SSCs are protected from missiles generated by tornadoes and extreme winds, and are designed and constructed as described in FSAR Tier 2. Therefore, the staff concludes that the missile protection provided for U.S. EPR structures against missiles generated by tornadoes and extreme winds complies with the requirements of 10 CFR 52.47(b)(1). The staff reviewed FSAR Tier 2, Revision 0, Section 3.5.1.4, against the guidance in SRP Section 14.3.7, Revision 3, “Plant Systems − Inspections, Tests, Analyses, and Acceptance Criteria,” and found that no additional ITAAC are needed in connection with this section.

Section 3.5.3 of this report addresses the staff's evaluation of the design of structures, shields, and barriers used for missile protection.

Section 3.8 of this report addresses the staff's evaluation of the design of Category I structures of the NI structures, including EPGBs, ESWBs and FB.

3.5.1.4.5 Combined License Information Items

Table 3.5.1.4-1 of this report provides a list of tornado missiles related COL Information Item numbers and descriptions from FSAR Tier 2, Table 1.8-2:

Table 3.5.1.4-1 U.S. EPR Combined License Information Items

Item No.	Description	FSAR Tier 2 Section
3.5-4	A COL applicant that references the U.S. EPR design certification will evaluate the potential for missiles generated by natural phenomena, such as hurricanes and extreme winds, and their potential impact on the missile protection design features of the U.S. EPR.	3.5.1.4
3.5-7	For sites with surrounding ground elevations higher than plant grade, a COL applicant that references the U.S. EPR design certification will confirm that automobile missiles cannot be generated within a 0.5 mile radius of safety-related SSCs that would lead to impact higher than 30 ft above plant grade.	3.5.1.4

The staff finds the above list of COL information items to be complete, and adequately describes the actions necessary for the COL applicant. No additional COL information items need to be included in FSAR Tier 2, Table 1.8-2 for missiles generated by tornadoes and extreme winds.

3.5.1.4.6 Conclusions

The staff's review concludes that the applicant's design-basis tornado parameters and tornado-generated missile spectra for the U.S. EPR design comply with the 10 CFR Part 50, Appendix A, GDC 2 and GDC 4 requirements for SSCs to be protected from missiles generated by the design-basis tornado and other extreme winds, because the applicant conforms with guidance recommended in RG 1.76 for design-basis tornado and tornado missiles for nuclear power plants.

3.5.1.5 *Site Proximity Missiles (Except Aircraft)*

GDC 4 requires, in part, that SSCs important to safety be protected against the dynamic effects, including the effects of missiles that may result from events and conditions outside the nuclear power unit. The potential threat to the plant from site proximity missiles is site-specific and will be addressed by the COL applicant by providing the site-specific information and analysis of site proximity explosions and potential missiles generated by these explosions. Missiles generated from nearby facilities are identified as a site parameter in the FSAR Tier 2, Table 1.8-1 (Item 3-1).

Table 3.5.1.5-1 below provides a list of site proximity missile related COL item numbers and descriptions from FSAR Tier 2, Table 1.8-2:

Table 3.5.1.5-1 U.S. EPR Combined License Information Items

Item No.	Description	FSAR Tier 2 Section
3.5-5	A COL applicant that references the U.S. EPR design certification will evaluate the potential for site proximity explosions and missiles generated by these explosions for their potential impact on missile protection design features.	3.5.1.5

The staff finds the above listing to be complete. Also, the list adequately describes actions necessary for the COL applicant. No additional COL information items need to be included in FSAR Tier 2, Table 1.8-2 for site proximity missile consideration.

3.5.1.6 *Aircraft Hazards*

GDC 3, "Fire Protection," requires in part, that SSCs important to safety be appropriately protected against the effects of fires. GDC 4 requires, in part, that SSCs important to safety be protected against dynamic effects, including the effects of missiles that may result from events and conditions outside the nuclear power unit. The potential threat to the plant from aircraft hazards is site-specific and will be addressed by the COL applicant by providing the site-specific information and analysis of aircraft hazards and their impact on plant SSCs. Aircraft hazards are identified as a site parameter in the FSAR Tier 2, Table 1.8-1 (Item 3-3).

Table 3.5.1.6-1 below provides a list of aircraft hazard related COL item numbers and descriptions from FSAR Tier 2, Table 1.8-2:

Table 3.5.1.6-1 U.S. EPR Combined License Information Items

Item No.	Description	FSAR Tier 2 Section
3.5-6	A COL applicant that references the U.S. EPR design certification will evaluate site-specific aircraft hazards and their potential impact on plant SSCs.	3.5.1.5

The staff finds the above listing to be complete. Also, the list adequately describes actions necessary for the COL applicant. No additional COL information items need to be included in FSAR Tier 2, Table 1.8-2 for site proximity missile consideration.

The post-September 11, 2001, security-related aircraft impact assessment of the U.S. EPR design is addressed in Section 19.2 of this report.

3.5.2 Structures, Systems, and Components to be Protected from Externally Generated Missiles

3.5.2.1 *Introduction*

To satisfy GDC 2 and GDC 4, safety-related SSCs needed to safely shut down the reactor and maintain it in a safe condition are protected from externally generated missiles. This includes all safety-related SSCs supporting the operation of reactor including essential service water intakes, buried components, and structure access openings and penetrations.

3.5.2.2 *Summary of Application*

FSAR Tier 1: The FSAR Tier 1 information associated with this section is found in FSAR Tier 1, Sections 2.1.1, 2.1.2, and 2.1.5, which describe the design of the NI Structures, EPGBs, and ESWBs, respectively.

FSAR Tier 2: The applicant has provided an FSAR Tier 2 description in Section 3.5.2, "Structures, Systems, and Components to be Protected from Externally Generated Missiles," summarized here in part, as follows:

FSAR Tier 2, Section 3.5.2 describes the SSCs requiring protection from externally generated missiles and the structures that are missile protected. The missile protected structures include the Reactor Building, Reactor Containment Building, Reactor Building Internal Structures, Safeguard Buildings, Fuel Building, Emergency Power Generating Buildings, and Essential Service Water Buildings. Missile protection for structures is provided by the external roof and walls of the structure.

ITAAC: The ITAAC associated with FSAR Tier 2, Section 3.5.2 are given in FSAR Tier 1, Tables 2.1.1-4, 2.1.2-3, and 2.1.5-3 and provide ITAAC requirements for the NI structures, EPGBs, and ESWBs, respectively.

Initial Testing: FSAR Tier 2, Section 14.2 does not have any initial testing requirements associated with this review item.

3.5.2.3 *Regulatory Basis*

The relevant requirements of NRC regulations for this area of review, and the associated acceptance criteria, are given in Section 3.5.2, "Structures, Systems, and Components to be Protected from Externally Generated Missiles," of NUREG-0800, Revision 3, March 2007, and are summarized below. Review interfaces with other SRP sections also can be found in SRP Section 3.5.2.

1. GDC 2 requires, in part, that SSCs important to safety shall be designed to withstand the effects of natural phenomena such as tornadoes and hurricanes without loss of capability to perform their safety functions.

2. GDC 4 requires, in part, that SSCs important to safety shall be appropriately protected against the effects of missiles that may result from events and conditions outside the nuclear power unit.

3. 10 CFR 52.47(b)(1) requires that a design certification application contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the design certification is built and will operate in accordance with the design certification, the provisions of the Atomic Energy Act, and NRC regulations.

3.5.2.4 *Technical Evaluation*

The staff reviewed the U.S. EPR design for protecting SSCs important to safety against externally generated missiles in accordance with the guidance of SRP Section 3.5.2, Revision 3, March 2007. The staff reviewed FSAR Tier 2, Section 3.5.2. The staff also reviewed FSAR Tier 1, Sections 2.1.1, 2.1.2, and 2.1.5, and other FSAR Tier 2 sections noted below.

Compliance with GDC 2 and GDC 4 is based on meeting the guidance of the following RGs:

- RG 1.13, "Spent Fuel Storage Facility Design Basis," Revision 2, March 2007, as it relates to the capacity of the spent fuel pool cooling (SFPC) systems and structures to withstand the effects of externally generated missiles and to prevent missiles from contacting the stored fuel assemblies.

- RG 1.27, "Ultimate Heat Sink for Nuclear Plants," Revision 2, as it relates to the capability of the ultimate heat sink and connecting conduits to withstand the effects of externally generated missiles.

- RG 1.115, Revision 1, as it relates to the protection of the SSCs important to safety from the effects of turbine missiles.

- RG 1.117, Revision 1, Appendix A, as it to which SSCs important to safety should be protected from missile impacts.

In SRP Section 3.5.2, Revision 3, the staff states that the SSCs required for safe shutdown of the reactor should be identified. RG 1.115, Position C.1 and RG 1.117 Appendix A, provide guidance as to which SSCs should be protected from missile impacts. In FSAR Tier 2, Table 3.2.2-1, the applicant identifies the SSCs that require missile protection, and in FSAR Tier 2, Section 7.4, the applicant identifies the SSCs that are needed for safe shutdown. Therefore, the staff concludes that the U.S. EPR plant design conforms to the guidance of RG 1.117.

U.S. EPR structures that provide protection for SSCs against externally generated missiles include:

- The RB annulus

- RB internal structures

- SB, including the main control room

- FB, including the spent fuel pool

- EPGBs

- ESWBs, each containing an ESWPB and an ESWCT

Safety-related pipes and cables routed outside of missile-protected structures are buried at a depth sufficient to provide missile protection, or routed in concrete or steel enclosures designed to withstand missile impact loads.

Section 3.5.3 of this report addresses the staff's evaluation of the design of structures, shields, and barriers used for missile protection.

In FSAR Tier 1, Section 2.1.1, the applicant states that the NI structures are constructed to withstand design-basis loads associated with normal operation and external events, including tornado-generated missiles. Similarly, in FSAR Tier 1, Sections 2.1.2 and 2.1.5, the applicant states that the EPGBs and ESWBs are also constructed to withstand design-basis loads associated with normal operation and external events, including tornado-generated missiles.

Section 3.8 of this report addresses the staff's evaluation of the design of Category I structures of the NI structures, including EPGBs, ESWBs and FB. Section 3.8 of this report also addresses the staff's evaluation of U.S. EPR structure conformance to the guidance of RG 1.13 with respect to protection of spent fuel from externally generated missiles.

Section 3.5.1.3 of this report addresses the staff's evaluation of the protection from low-trajectory turbine missiles, including the evaluation of U.S. EPR structure conformance to the guidance of RG 1.115.

In reviewing FSAR Tier 2, Section 3.5.2, the staff identified areas in which additional information was necessary to complete the evaluation of the U.S. EPR plant design for protection against external missiles generated by natural phenomena. Therefore, in RAI 94, Question 03.05.02-1, the staff requested that the applicant address missile protection provided for the U.S. EPR design. The staff's RAIs, applicant's responses, and the staff's evaluation of the applicant's responses are provided below.

RG 1.27 Position C.2 and C.3, in part, specifies that the ultimate heat sink complex should be capable of withstanding the effects of external missiles generated by natural phenomena without loss of the sink safety functions, such that it complies with GDC 2.

Each of the ESWBs houses an ESWCT and an ESWPB. In FSAR Tier 1, Section 2.1.5, the applicant stated that the ESWBs are designed to withstand the effects of earthquakes, tornadoes, floods, and tornado-generated missiles. However, FSAR Tier 2, Figure 3.8-101, "Essential Service Water Building Section A-A," and FSAR Tier 2, Figure 3.8-102, "Essential Service Water Building Section B-B" show:

- the ESWCT open at Elevation 29.3 m (96 ft) with the fan below potentially susceptible to a missile impact

- equipment hatches at Elevation 19.2 m (63 ft) on the ESWPB roof deck, which are potentially susceptible to vertical impacts from tornado-generated missiles

Therefore, the staff initiated RAI 94, Question 03.05.02-1, and requested the applicant to provide discussion/analysis in the FSAR to demonstrate that the ESWCT fan and ESWPB roof deck are capable of withstanding vertical impact from a tornado-generated missile.

In a November 10, 2008, response to RAI 94, Question 03.05.02-1, the applicant clarified that:

- The ESWCT fan is protected from impact by a missile shield at Elevation 25 m (82 ft) as shown in FSAR Tier 2, Figure 3.8-102.
- The roof deck at Elevation 19.2 m (63 ft) is an external slab and is, therefore, sized for protection against tornado-generated missiles. All equipment hatches are sized the same thickness as the roof as shown in FSAR Tier 2, Figure 3.8-101 and are, therefore, capable of withstanding a tornado-generated missile.

The staff finds the above applicant response to RAI 94, Question 03.05.02-1 acceptable, because it clarifies that the ESWCT fan and the ESWPB roof deck and hatch are adequately protected against external hazards and tornado-generated missiles. Therefore, the staff considers its concern described in RAI 94, Question 03.05.02-1 resolved and further concludes that the ultimate heat sink complex design is in conformance with the guidance of RG 1.27.

A missile-induced failure of a non-safety-related SSC could prevent a safety-related SSC from completing its safety function. In FSAR Tier 2, Section 3.5.2, the applicant stated that FSAR Tier 2, Section 3.3.2.3, "Effect of Failure of Structures or Components not Designed for Tornado Loads," evaluated the effects that failures of structures or components not designed for tornado loads, including missile impact, could have on nearby safety-related structures. However, the effects of missile impact were not discussed in FSAR Tier 2, Section 3.3.2.3. Therefore, in RAI 94, Question 03.05.02-1, the staff requested that the applicant provide discussion/analysis to determine whether missile induced failure of non-safety-related SSCs could prevent a safety related SSC identified as requiring protection from externally-generated missiles from completing its safety function.

In a November 10, 2008, response to RAI 94, Question 03.05.02-1, the applicant clarified that FSAR Tier 2, Section 3.3.2.3 discusses how the effects of failures of non-seismic structures or components are evaluated and that the Seismic Category I structures are protected from the failure of adjacent non-Seismic Category I structures during a tornado event.

Section 3.7.3 of this report addresses the staff's evaluation of the design of non-seismic SSCs which, if they fail, could potentially create seismic-generated missiles that could affect safety-related SSCs.

Section 3.8 of this report addresses the staff's evaluation of the design of Category I structures, including the protection of these structures from the effects resulting from the failure of adjacent non-Seismic Category I structures during a tornado event.

<u>ITAAC</u>

10 CFR 52.47(b)(1) requires that a design certification application contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the design certification is built and will operate in accordance with the design certification, the provisions of the Atomic Energy Act, and NRC regulations.

In FSAR Tier 1, Section 2.0, the applicant provides the design descriptions and ITAAC that verify that the following structures to be protected from externally-generated missiles are designed and constructed as described in FSAR Tier 2:

Nuclear Island

The NI consists of all of the structures supported by the NI common basemat structures foundation basemat. The NI includes the RB, SBs, FB, MSV, and MFV stations.

ITAAC Item 3.7 listed in FSAR Tier 1, Table 2.1.1-4, requires a verification inspection of the NI structures design analyses versus construction records to ensure that the structures have been constructed in accordance with the design as described in U.S. EPR Tier 2.

Emergency Power Generating Buildings

The EPGBs are safety-related, Seismic Category I, reinforced-concrete structures supported by a reinforced-concrete basemat. There are two essentially identical EPGBs (EPGB 1/2 and EPGB 3/4) located adjacent to the NI.

ITAAC Items 3.3 and 3.4 listed in FSAR Tier 1, Table 2.1.2-3 requires verification that the EPGB structures are Seismic Category I and have been constructed in accordance with the design to withstand design basis loads as described in FSAR Tier 2.

Essential Service Water Buildings

Each of the four ESWBs is an independent, safety related, Seismic Category I, reinforced-concrete structure. Each ESWB houses an ESWCT and an ESWPB. The ESWCT houses two cooling towers and a water storage basin. The ESWPB houses pumps and electrical equipment. A total of four ESWBs are located in pairs on each side of the NI complex.

ITAAC Items 3.2, 3.4, and 3.5 listed in FSAR Tier 1, Table 2.1.5-3 require verification that the ESWB structures are four separate ESWBs and have been constructed in accordance with the design to withstand design basis loads as specified as described in U.S. EPR Tier 2.

The staff finds that the above cited ITAAC Items, which verify that the safety-related SSCs are protected from externally-generated missiles and have been constructed in accordance with the design as described in U.S. EPR Tier 2, are acceptable. Therefore, the staff concludes that the missile protection provided for U.S. EPR structures complies with the requirements of 10 CFR 52.47(b)(1).

3.5.2.5 *Combined License Information Items*

Table 3.5.2.5-1 of this report provides a list of externally generated missile related COL Information Item numbers and descriptions from FSAR Tier 2, Table 1.8-2:

Table 3.5.2.5-1 U.S. EPR Combined License Information Items

Item No.	Description	FSAR Tier 2 Section
3.3-3	A COL applicant that references the U.S. EPR design certification will demonstrate that failure of site-specific structures or components not included in the U.S. EPR standard plant design, and not designed for tornado loads, will not affect the ability of other structures to perform their intended safety functions.	3.3.2

The staff finds the above listing to be complete. Also, the list adequately describes actions necessary for the COL applicant. No additional COL information items need to be included in FSAR Tier 2, Table 1.8-2 for externally generated missile considerations.

3.5.2.6 *Conclusions*

Based on the staff's review of the information provided in the FSAR Tier 1 and Tier 2, which is documented in the staff's evaluation set forth above, the staff concludes that the SSCs to be protected from externally-generated missiles are in conformance with the guidance described in RG 1.13, RG 1.27, RG 1.115, and RG 1.117 and, therefore, comply with the requirements of GDC 2 and GDC 4. The staff further concludes that adequate protection features have been provided for the U.S. EPR design to protect safety-related SSCs against externally generated missiles.

3.7 Seismic Design

3.7.4 Seismic Instrumentation

3.7.4.1 *Introduction*

Installation of instrumentation that is capable of adequately measuring the effects of an earthquake at the plant site is addressed in this section. The criteria for the seismic instrumentation include the following:

- Comparison with RG 1.12, "Nuclear Power Plant Instrumentation for Earthquakes"
- Location and description of instrumentation
- Control room operator notification
- Comparison of measured and predicted responses
- Tests and inspections

3.7.4.2 *Summary of Application*

FSAR Tier 1: The FSAR Tier 1 information associated with this section is found in FSAR Tier 1, Section 2.4.7, which describes the seismic monitoring system (SMS).

FSAR Tier 2: The applicant has provided an FSAR Tier 2 description of the seismic instrumentation in FSAR Tier 2, Section 3.7.4, summarized here in part as follows:

FSAR Tier 2, Section 3.7.4 describes the seismic instrumentation and procedures necessary to promptly evaluate the seismic response of nuclear power plant features important to safety after an earthquake and to determine if vibratory ground motion exceeding that of the operating basis earthquake (OBE) ground motion has occurred. FSAR Tier 2, Section 3.7.4 also provides a list of the relevant regulations and regulatory guides.

The seismic instrumentation program described in FSAR Tier 2, Section 3.7.4 specifies the location and description of instrumentation, type of accelerograph, recording and playback equipment, control room operator notification, comparison of measured and predicted responses, and inservice surveillance. Specifically, in FSAR Tier 2, Section 3.7.4.2.1, the applicant indicated that field mounted sensors of the triaxial type (i.e., three directional, x-y-z axes) are rigidly mounted at the following locations:

1. Free field, if a suitable location is available.

2. The primary containment structure (base foundation and two higher elevations).

3. An independent Seismic Category I structure (foundation and higher elevations) not influenced by or connected to the primary containment structure.

The FSAR further states that the in-structure instrumentation is placed at locations modeled as mass points in the building dynamic analysis so that the measured motion can be directly compared with the design spectra. In addition, the FSAR refers to the Cumulative Absolute Velocity (CAV) cited in RG 1.166 as an alternative criterion to shut down an U.S. EPR plant.

ITAAC: The ITAAC associated with FSAR Tier 2, Section 3.7.4 are given in FSAR Tier 1, Table 2.4.7-1 and provide ITAAC requirements for the SMS.

3.7.4.3 *Regulatory Basis*

The relevant requirements of NRC regulations for this area, and the associated acceptance criteria, are given in NUREG-0800, Section 3.7.4 and are summarized below. Review interfaces with other SRP sections also can be found in NUREG-0800, Section 3.7.4.

1. 10 CFR Part 50, GDC 2, indicates that the design basis shall reflect appropriate consideration of the most severe earthquakes reported to have affected the site and surrounding area with sufficient margin for the limited accuracy, quantity, and period of time in which historical data have been accumulated.

2. 10 CFR Part 50, Appendix S, requires that suitable instrumentation be provided to promptly evaluate the seismic response of nuclear power plant features important to safety after an earthquake. Appendix S also requires shut down of the nuclear power plant if vibratory ground motion exceeding that of the OBE occurs.

Acceptance criteria adequate to meet the above requirements include:

1. RG 1.12 as it relates to nuclear power plant instrumentation for earthquakes.

2. RG 1.166, "Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Post Earthquake Actions," as it relates to pre-earthquake planning and immediate nuclear power plant operator post earthquake actions.

3.7.4.4 *Technical Evaluation*

The staff reviewed the list of regulatory guides and the description provided in FSAR Tier 2, Section 3.7.4 of the seismic instrumentation program and procedures to ensure that the relevant requirements of GDC 2, as well as 10 CFR Part 50, Appendix S and 10 CFR 100.23 can be met by potential COL applicants. Paragraph IV(a)(4) of Appendix S requires that suitable instrumentation be provided so that the seismic response of nuclear power plant features important to safety can be evaluated promptly after an earthquake. 10 CFR Part 50, Appendix S, Paragraph IV(a)(3) requires shut down of the nuclear power plant if vibratory ground motion exceeding that of the OBE occurs.

The staff reviewed the seismic instrumentation program described in the FSAR Tier 2, Section 3.7.4 to determine whether the instrumentation program provides an adequate number of instruments in suitable locations capable of recording a suitable range of earthquake strong ground motions. The staff also notes that ITAAC Item 2.1, listed in FSAR Tier 1, Table 2.4.7-1 requires analyses to be performed to determine that the location of the SMS equipment is as described in FSAR Tier 1, Section 2.1. The staff reviewed FSAR Tier 1, Section 2.1 and was not able to find the description of the SMS locations. As a result in RAI 400, Question 03.07.04-7, the staff requested the applicant to specify the correct FSAR Tier 1 Section which provides the location of the SMS equipment. **RAI 400, Question 03.07.04-7, which is associated with the above request, is being tracked as an open item.**

The staff determined that the instrumentation program, in general, conforms to the guidance provided RG 1.12. However, in RAI 73, Question 03.07.04-1, the staff requested that the applicant provide additional information regarding the seismic monitoring instrumentation system backup battery charger in case of power outage or power failure. In an October 30, 2008, response to RAI 73, Question 03.07.04-1, the applicant referred to FSAR Tier 2, Section 3.7.4.2.5 which states the following:

> The system components are powered from the plant supplied, non-vital battery backed uninterruptible power supply (UPS) to provide continuous operation following a station blackout. A backup battery system is provided for each recorder adequate to supply to the equipment for a minimum of 25 minutes in a 24-hour period without charging. The system equipment cabinet includes an internal UPS and charger capable of operating the central controller and support equipment.

To provide clarification, the applicant also noted in their response that the charger refers to the instrumentation battery charger, which is considered a system component. The applicant also stated that the seismic monitoring system components, including the battery charger, receive power from the non-vital UPS as stated above, which is in compliance with RG 1.12. The staff concludes that the applicant's response provides an adequate description of the seismic monitoring system backup battery charger in case of power outage or power failure that conforms to the guidance provided in RG 1.12. Furthermore, ITAAC Item 4.1, listed in listed in FSAR Tier 1, Table 2.4.7-1, requires verification that the SMS has a backup battery has a capacity for a minimum of 25 minutes of system operation. The staff concludes that this ITAAC Item is acceptable because its acceptance criteria conforms to the guidance provided in RG 1.12. The staff reviewed the dynamic range and trigger threshold specified for each instrument in addition to specifications for control room operator notification. The staff notes that ITAAC Items 3.2, 3.3, 3.4, and 3.5, listed in FSAR Tier 1, Table 2.4.7-1, requires tests and/or analyses to ensure that the SMS has sufficient a dynamic range, bandwidth, and sampling rate, respectively. The staff finds that the above cited ITAAC Items, which have been constructed according to the guidance in RG 1.12, are acceptable.

The staff also reviewed the description of the ground motion threshold values used to determine if plant shutdown is necessary. In RAI 73, Question 03.07.04-4, the staff requested that the applicant clarify whether all three components of the recorded motion (five percent of critical damping response spectra) from the free-field sensor (or the foundation level sensor) would be compared with the OBE response spectrum. The staff also requested that the applicant provide additional details regarding the criteria for exceedance of the OBE response spectrum. In an October 30, 2008, response to RAI 73, Question 03.07.04-4, the applicant stated that all three components of the recorded motion (five percent of critical damping response spectra) from the free-field sensor (or the foundation level sensor) would be compared with the OBE response spectrum, which conforms to the guidance provided RG 1.166. In addition, the applicant stated that the criteria for exceedance of the OBE response spectrum is as stated in RG 1.166, Regulatory Position 4.1.2. In addition, in RAI 73, Question 03.07.04-5, the staff requested that the applicant provide additional details regarding the CAV check including the criteria for shutdown based on CAV. In an October 30, 2008, response to RAI 73, Question 03.07.04-5, the applicant stated that the criteria for exceedance of the CAV limit are consistent with the guidance provided in RG 1.166. Specifically, the CAV limit is exceeded if the CAV value is greater than 0.16 g-second as calculated according to the procedures in Electric Power Research Institute (EPRI) Topical Report TR-100082, "Standardization of the Cumulative Absolute Velocity," December 1991. The staff concludes that the applicant's responses to RAI 73, Questions 03.07.04-5 and 03.07.04-4 conforms to the guidance provided in RG 1.166, and are therefore acceptable. In addition, ITAAC Item 3.1, listed in FSAR Tier 1, Table 2.4.7-1, requires verification that the SMS can compute the CAV and provides a display of the CAV in the MCR. The staff finds that the above cited ITAAC Item, which verifies that the CAV exceedance check can be computed by the SMS and displayed in the MCR and has been constructed in accordance with the methodology outlined in FSAR Tier 2, Section 3.7.4, is acceptable.

In addition, the staff also reviewed the procedures for surveillance to ensure continual operation of each of the seismic instruments. The staff issued the applicant two RAIs related to instrument maintenance and surveillance. In RAI 73, Question 03.07.04-2, the staff requested that the applicant provide additional information regarding the scheduled time intervals for channel checks. In an October 30, 2008, response to RAI 73, Question 03.07.04-2, the applicant stated that periodic channel checks, functional tests, and calibration intervals would be performed in accordance with RG 1.12. Specifically, the applicant referenced the surveillance intervals listed in RG 1.12, Regulatory Position 8.2, and for this reason, the staff determined the applicant's response to RAI 73, Question 03.07.04-2 to be acceptable In RAI 73, Question 03.07.04-3, the staff noted that the applicant did not describe the provisions for a file containing the pertinent information on all the seismic instrumentation to be maintained and requested that the applicant provide information regarding the seismic instrumentation program as specified in RG 1.166, Regulatory Position 1.1. In an October 30, 2008, response to RAI 73, Question 03.07.04-3, the applicant stated that a file containing information on all of the seismic instrumentation (i.e., instrument type, plan and vertical section views, service history, and suitable earthquake time history) will be maintained in conformance with RG 1.166. Thus, the staff concludes that the applicant's response is adequate.

FSAR Tier 2, Section 3.7.4 specifies that a seismic instrument should be located in the free field only if a suitable location is available. However, RG 1.12 specifies that a seismic instrument be located in the free-field and RG 1.166 states that the evaluation to determine whether the OBE has been exceeded should be performed using the ground motion recorded from a free-field instrument. As such, the staff requested that the applicant provide the following information:

1. Clarify the criteria for a "suitable location" for installing a free field seismic sensor.

2. Justify how the OBE exceedance will be determined by seismic instrument installed on structures.

3. Explain if CAV threshold of shutdown is still applicable if there is no free field sensor available (no suitable location).

RAI 381, Question 03.07.04-6, which is associated with the above request, is being tracked as an open item.

3.7.4.5 *Combined License Information Items*

Table 3.7.4.5-1 of this report provides a list of seismic instrumentation related COL Information Item numbers and descriptions from FSAR Tier 2, Table 1.8-2:

Table 3.7.4.5-1 U.S. EPR Combined License Information Items

Item No.	Description	FSAR Tier 2 Section
3.7-4	A COL applicant that references the U.S. EPR design certification will determine whether essentially the same seismic response from a given earthquake is expected at each of the units in a multi-unit site or instrument each unit. In the event that only one unit is instrumented, annunciation shall be provided to each control room.	3.7.4.2
3.7-5	A COL applicant that references the U.S. EPR design certification will determine if a suitable location exists for the free-field acceleration sensor. The mounting location must be such that the effects associated with surface features, buildings, and components on the recordings of ground motion are insignificant. The acceleration sensor must be based on material representative of that upon which the Nuclear Island (NI) and other Seismic Category I structures are founded.	3.7.4.2.1

The staff finds the above listing to be complete. Also, the list adequately describes actions necessary for the COL applicant. No additional COL information items need to be included in FSAR Tier 2, Table 1.8-2 for seismic instrumentation considerations.

3.7.4.6 *Conclusions*

Based on its review of FSAR Tier 2, Section 3.7.4, the staff concludes that the applicant has adequately described the seismic instrumentation program and procedures to ensure that potential COL applicants can meet the relevant requirements of GDC 2, as well as those of 10 CFR Part 50, Appendix S with the exception of RAI 381, Question 03.07.04-6. The applicant also provided a list of the applicable regulations and regulatory guides.

3.8 Design of Category I Structures

3.9 Mechanical Systems and Components

3.9.6 Functional Design, Qualification, and Inservice Testing Programs for Pumps, Valves, and Dynamic Restraints

3.9.6.1 *Introduction*

This section evaluates the descriptions of the functional design, qualification, and inservice testing (IST) programs for safety-related pumps, valves, and dynamic restraints (snubbers) used in the U.S. EPR design provided in the design certification application.

3.9.6.2 *Summary of Application*

FSAR Tier 1: There are no FSAR Tier 1 requirements specific to the IST program for the U.S. EPR. The system-based descriptions of FSAR Tier 1, Chapter 2 address ASME design-related Code requirements for system components.

FSAR Tier 2: In FSAR Tier 2, Section 3.9.6, the applicant describes the functional design and qualification provisions and IST programs for safety-related pumps, valves, and dynamic restraints typically designated as ASME B&PV Code Class 1, 2, or 3 for use in the U.S. EPR. In FSAR Tier 2, Table 3.9.6-1, "Inservice Pump Testing Program Requirements," and FSAR Tier 2, Table 3.9.6-2, "Inservice Valve Testing Program Requirements," the applicant lists pumps and valves within the scope of the IST program described in support of the U.S. EPR design certification application, and their applicable functions, inservice tests, and test intervals, respectively.

The ASME Code for Operation and Maintenance of Nuclear Power Plants (OM Code) establishes preservice testing (PST) and IST and examination requirements for components to assess their operational readiness as incorporated by reference in 10 CFR 50.55a. The application states that pumps and valves will be tested within the IST program to confirm that these components are capable of performing their intended safety functions. FSAR Tier 2, Chapter 15, "Transient and Accident Analyses," safety analyses contain information on the functional design, or intended safety function, of pumps and valves. The application indicates that the IST program will provide for pump and valve testing over the full range of system differential pressures, flowrates, temperatures, and available voltages (as applicable), from normal operating to design-basis conditions and considers degraded flow that may occur during post-accident conditions. IST testing will also be performed on RCPB valves to demonstrate that they will not experience leakage, or increased leakage, from their loading. The application states that the IST of safety-related pumps, valves and snubbers will be performed in accordance with 10 CFR 50.55a(f), the 2004 edition of the ASME,OM Code, and the guidance in RG 1.192, "Operation and Maintenance Code Case Acceptability, ASME OM Code," and NUREG-1482, Revision 1, "Guidelines for Inservice Testing at Nuclear Power Plants."

The application states that the U.S. EPR design provides ready access to systems and components to facilitate comprehensive testing using currently available equipment and techniques. The application indicates that the system design incorporates provisions, including alternate flow paths and necessary instrumentation, to allow full flow testing of pumps and valves under the IST program.

ITAAC: There are no ITAAC specific to IST programs. The system-based descriptions of FSAR Tier 1, Chapter 2 address ASME Code design-related requirements for system components. ITAAC have been established for specific components to confirm that their design provisions have been met.

Technical Specifications: FSAR Tier 2, Chapter 16, "Technical Specifications," specifies various component-related technical specifications that require licensees, for example, to verify each specify component is operable in accordance with the IST program, and at a frequency in accordance with the IST program.

3.9.6.3 *Regulatory Basis*

The relevant requirements of NRC regulations for functional design, qualification, and IST programs for pumps, valves, and dynamic restraints and the associated acceptance criteria are listed in SRP Section 3.9.6, "Functional Design, Qualification, and Inservice Testing Programs for Pumps, Valves, and Dynamic Restraints," and are summarized below.

1. 10 CFR Part 50, Appendix A, GDC 1, "Quality Standards and Records," as it relates to pumps, valves, and dynamic restraints important to safety being designed, fabricated, tested, and inspected to quality standards commensurate with the importance of the safety functions to be performed.

2. GDC 2, as it relates to pumps, valves, and dynamic restraints important to safety to withstand the effects of natural phenomena combined with the effects of normal and accident conditions.

3. GDC 4, as it relates to designing pumps, valves, and dynamic restraints important to safety to accommodate the effects of and to be compatible with the environment conditions associated with normal operation, maintenance, testing, and postulated accidents.

4. GDC 14, "Reactor Coolant Pressure Boundary," as it relates to designing pumps, valves, and dynamic restraints that form the reactor coolant boundary so as to have an extremely low probability of abnormal leakage, rapidly propagating failure, and gross rupture.

5. GDC 15, "Reactor Coolant System Design," as it relates to pumps, valves, and dynamic restraints that form the reactor coolant system being designed with sufficient margin to ensure that the design conditions are not exceeded.

6. GDC 37, "Testing of Emergency Core Cooling System," as it relates to designing the emergency core cooling to permit periodic functional testing to ensure the leak tight integrity and performance of its active components.

7. GDC 40, "Testing of Containment Heat Removal System," as it relates to designing the containment heat removal system to permit functional testing to ensure leak tight integrity and the performance of its active components.

8. GDC 43, "Testing of Containment Atmosphere Cleanup Systems," as it relates to designing the containment atmospheric cleanup systems to permit periodic functional testing to ensure the leak tight integrity and the performance of the active components.

9. GDC 46, "Testing of Cooling Water System," as it relates to designing the cooling water system to permit periodic functional testing to ensure the leak tight integrity and performance of the active components.

10. GDC 54, "Piping Systems Penetrating Containment," as it relates to designing piping systems penetrating containment with the capability to test periodically the operability of the isolation valves and determine valve leakage acceptability.

11. 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," as it relates to quality assurance in the design, fabrication, construction, and testing of safety-related pumps, valves, and dynamic restraints.

12. 10 CFR 50.55a(c) through (e), "Codes and standards," in so far as they incorporate the ASME Code, Section III, as it relates to the design of mechanical equipment and supports.

13. 10 CFR 50.55a(f) for pumps and valves, and 10 CFR 50.55a(g) for dynamic restraints, as they relate to design and accessibility for performance of IST activities.

14. 10 CFR 50.55a(b)(3)(ii), as it relates to design and accessibility for implementation of the motor-operated valve (MOV) periodic testing program.

15. 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," as it relates to certification of a standard reactor design.

The staff followed SRP Section 3.9.6 and its acceptance criteria in reviewing the descriptions of the functional design, qualification, and IST programs for pumps, valves, and dynamic restraints to be used in the U.S. EPR design.

The Commission's September 11, 2002, SRM for Commission Paper SECY-02-0067, "Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) for Operational Programs (Programmatic ITAAC)," stated that ITAAC for an operational program are unnecessary if the program and its implementation are fully described in a COL application and found to be acceptable by the NRC. In its SRM for SECY-04-0032, May 14, 2004, the Commission defined "fully described" as when the program is clearly and sufficiently described in terms of the scope and level of detail to allow a reasonable assurance finding of acceptability. The Commission also noted that required programs should always be described at a functional level and at an increasing level of detail where implementation choices could materially and negatively affect the program effectiveness and acceptability. Commission Paper SECY-05-0197, "Review of Operational Programs in a Combined License Application and Generic Emergency Planning Inspections, Tests, Analyses, and Acceptance Criteria," summarizes the NRC position regarding the full description of operational programs to be provided by COL applicants. RG 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)," provides guidance in Section C.IV.4 for COL applicants with respect to fully describing plant operational programs. At a public meeting of the U.S. EPR Design Center Working Group (DCWG) on March 4, 2009, the design certification applicant stated that its FSAR would fully describe the functional design, qualification, and IST programs for the U.S. EPR to allow COL applicants to incorporate by reference the descriptions of these programs in their COL applications with only plant-specific information needed to supplement the program descriptions. Therefore, the staff followed the guidance in SECY-05-0197 and RG 1.206, in addition to SRP Section 3.9.6, in reviewing the descriptions of the functional design and qualification, and IST programs for pumps, valves, and dynamic restraints to be used in the U.S. EPR design.

3.9.6.4 *Technical Evaluation*

In Section 3.9.3 of this report, the staff discusses the design of plant equipment, including safety-related pumps, valves, and dynamic restraints, for the U.S. EPR. The load combinations and stress limits used in the design of pumps and valves ensure maintenance of the integrity of the component pressure boundary. The functional design and qualification of pumps, valves, and dynamic restraints must be sufficient to demonstrate their capability to perform their design-basis functions. In addition, a licensee will periodically test the performance and measure performance parameters of safety-related pumps, valves, and snubbers in accordance with 10 CFR 50.55a(f). The regulations require comparison of periodic measurements of various parameters to baseline measurements to detect long-term degradation of component performance and to assess their operational readiness.

The staff evaluated U.S. EPR FSAR Tier 2, Section 3.9.6 and its associated sections to determine whether the FSAR provisions are sufficient to demonstrate the functional design, qualification, and IST programs for pumps, valves, and dynamic restraints will satisfy the requirements of NRC regulations and the ASME OM Code as incorporated by reference in the regulations. As part of this review, the staff assessed the adequacy of the U.S. EPR design to ensure that it provided access to allow IST activities for pumps, valves, and snubbers.

3.9.6.4.1 Functional Design and Qualification of Pumps, Valves, and Dynamic Restraints

FSAR Tier 2, Section 3.9.3.3, “Pump and Valve Operability Assurance,” and FSAR Tier 2, Section 3.9.3.4, “Component Supports,” provide a general description of the functional design and qualification of pumps and valves, and snubbers, respectively, for the U.S. EPR. For example, FSAR Tier 2, Section 3.9.3.3 states that active pump and valve operability will be established initially by subjecting the pump and valve to factory tests prior to installation. FSAR Tier 2, Section 3.9.3.3 specifies that factory pump tests include a hydrostatic test for pressure retaining parts, pump seal leakage tests to hydrostatic test pressure, and performance tests to establish pump head provisions. In accordance with the FSAR provisions, factory valve tests include a shell hydrostatic test, valve closure test, and performance test to verify correct opening and closing of the valve, and are followed by post-installation testing. FSAR Tier 2, Section 3.9.6.1, “Functional Design and Qualification of Pumps, Valves, and Dynamic Restraints,” states that safety-related power-operated valves (POVs) are qualified to perform their design-basis functions either before installation or as part of preservice tests. The staff reviewed the FSAR design provisions for pump and valve operability assurance and component support capability provided in FSAR Tier 2, Sections 3.9.3 and 3.9.6.

FSAR Tier 2, Section 3.9.3.4 addresses design considerations for component supports. FSAR Tier 2, Section 3.9.3.4.5, “Use of Snubbers,” references AREVA Topical Report ANP-10264NP, “U.S. EPR Piping Analysis and Pipe Support Design Topical Report,” and also states that FSAR Tier 2, Section 3.9.6 provides a description of the functional design and qualification provisions for snubbers. Topical Report ANP-10264NP-A includes an NRC safety evaluation that references COL Applicant Responsibility Item 7 in Table 1-1 of ANP-10264NP-A, which provides that the COL applicant will perform the pipe stress and support analysis. The NRC safety evaluation for the topical report also indicates that the applicant stated in an RAI response that the snubber design specifications will be the responsibility of the COL applicant as noted in COL Applicant Responsibility Item 1 in Table 1-1 of ANP-10264NP-A. In RAI 49, Question 03.09.06-11, the staff requested that the U.S. EPR design certification applicant describe how clearances and different snubber activation and release rates will be addressed in the snubber design process. In a June 11, 2009, response to RAI 49, Question 03.09.06-11, the applicant noted that the criteria for the design of snubbers, including clearances, are provided in ANP-10264NP-A, Section 6.6. The applicant proposed to revise FSAR Tier 2, Section 3.9.6.1 to add a reference to AREVA NP Topical Report ANP-10264NP-A, Section 6.6, related to the design of snubbers. Because an NRC safety evaluation accepts ANP-10264NP-A for the design of snubbers, the staff finds the proposed FSAR change to be sufficient to resolve this RAI. **RAI 49, Question 03.09.06-11, which is associated with the above request, is being tracked as a confirmatory item**.

FSAR Tier 2, Sections 3.9.3.3 and 3.9.3.4 state that FSAR Tier 2, Section 3.9.6 provides a description of the functional design and qualification provisions for pumps, valves, and snubbers. While FSAR Tier 2, Section 3.9.6.1 states that the "functional design and qualification of each safety-related pump and valve is performed such that each pump and valve is capable of performing its intended function for a full range of system differential pressure and flow, ambient temperatures, and available voltage (as applicable) under conditions ranging from normal operating to design-basis accident conditions," this FSAR section focuses on IST rather than functional design and qualification. As discussed below, the staff has determined that the current provisions in FSAR Tier 2, Section 3.9.3.3 and Section 3.9.6 are not sufficient to adequately describe a program that will provide reasonable assurance of the design-basis capability of pump, valves, and dynamic restraints for the U.S. EPR.

As documented in numerous NRC generic communication issuances, weaknesses in the design programs for plant components used at operating nuclear power plants have resulted in situations in which valves might not have been able to perform their safety-related functions under design-basis conditions. These generic communications have included, for example, Generic Letter (GL) 89-10, "Safety-Related Motor-Operated Valve Testing and Surveillance," GL 95-07, "Pressure Locking and Thermal Binding of Safety-Related Power-Operated Gate Valves," GL 96-05, "Periodic Verification of Design-Basis Capability of Safety-Related Motor-Operated Valves," Regulatory Issue Summary (RIS) 2000-03, "Resolution of Generic Issue 158: Performance of Safety-Related Power-Operated Valves Under Design Basis Conditions," Information Notice (IN) 96-48 and its Supplement 1, "Motor-Operated Valve Performance Issues," and NUREG-1275, "Operating Experience Feedback Report." As a result of the lessons learned from nuclear power plant operating experience and NRC and industry research programs, the staff has provided guidance related to the functional design of safety-related pumps, valves, and dynamic restraints in SRP Section 3.9.6; RG 1.206, and RG 1.100, "Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants." One lesson learned from nuclear power plant operating experience and research programs is that the IST provisions of the ASME OM Code alone do not adequately provide assurance of the design-basis capability of safety-related valves.

Based on its review of the U.S. EPR design certification application in light of nuclear power plant operating experience and research programs, the staff determined that the applicant appeared to rely on the ASME OM Code alone. Accordingly, the staff determined that the applicant needs to establish a design process that will provide assurance that pumps, valves, and dynamic restraints will be capable of performing their safety functions. In particular, the staff needs additional information to evaluate whether components important to safety (including pumps, valves, and dynamic restraints) will be designed to perform their intended safety function under design-basis conditions (e.g., will function when subjected to the design-basis conditions that are to be considered during both normal operation and abnormal events within the design basis of the plant). Therefore, in RAI 49, Question 03.09.06-1, the staff requested that the design certification applicant describe its plans to provide assurance of the design-basis capability of pumps, valves, and dynamic restraints for the U.S. EPR design.

In a June 11, 2009, response to RAI 49, Question 03.09.06-1, the applicant indicated that it intended to use ASME QME-1-2007, "Qualification of Active Mechanical Equipment Used in Nuclear Power Plants," as guidance for qualifying active mechanical equipment. However, the applicant did not provide an FSAR markup indicating that it would follow all of the provisions of ASME QME-1-2007, nor are the current provisions in the U.S. EPR FSAR Tier 2 for design testing in Sections 3.9.3 and 3.9.6 sufficient to allow the staff to evaluate the process for the functional design and qualification to ensure the systematic review and documentation of the design basis for safety-related pumps, valves, and snubbers. For example, the design process should include consideration of the maximum differential pressure and flow rate expected during operation of the component for both normal operations and abnormal events, to the extent that these operations and events are part of the design basis. One acceptable method for providing assurance that active mechanical equipment (such as pumps, valves, and dynamic restraints) will meet their design-basis functional capability is specified in ASME QME-1-2007, as accepted by the staff in Revision 3 to RG 1.100. ASME QME-1-2007 incorporates lessons learned from valve testing and research programs performed by the nuclear industry and NRC Office of Nuclear Regulatory Research. As a result, the staff issued follow-up RAI 381, Question 03.09.06-15, to request that the applicant revise the U.S. EPR FSAR to adequately describe the functional design and qualification process for pumps, valves, and dynamic restraints (or specify implementation of QME-1-2007 as accepted in RG 1.100, Revision 3), with examples of the implementation of the FSAR provisions in the design specifications made available for NRC audit. **RAI 381, Question 03.09.06-15, which is associated with the above request, is being tracked as an open item**.

FSAR Tier 2, Section 3.9.6.1 indicates that the IST program provides for pump and valve testing over the full range of system differential pressures, flow-rates, temperatures, and available voltages (as applicable) from normal operating to design-basis conditions and considers degraded flow that may occur during post-accident conditions. The staff was unable to confirm that safety-related systems were provided with full-flow test capabilities on design drawings. This was the subject of RAI 49, Question 03.09.06-3. In a June 11, 2009 response to RAI 49, Question 03.09.06-3, the applicant explained how each safety-related pump was capable of being tested at the accident assumed flow rates. In regard to safety-related valves, the applicant referred to the test procedures, acceptance criteria, and corrective actions specified in the ASME OM Code. As discussed above, the ASME OM Code inservice test alone cannot be used to demonstrate the design-basis capability of safety-related valves. As a result, the staff issued follow-up RAI 381, Question 03.09.06-16, to request that the applicant revise the U.S. EPR FSAR to describe the testing and/or analysis performed to demonstrate the design-basis capability of safety-related valves. **RAI 381, Question 03.09.06-16, which is associated with the above request, is being tracked as an open item**.

3.9.6.4.2 Inservice Testing Program

In its review of the design certification application, the staff evaluated whether the design certification application provides assurance that IST provisions of the ASME OM Code referenced in the FSAR can be performed, and that the U.S. EPR systems and components provide access to permit the performance of testing pursuant to 10 CFR 50.55a(f). As part of a COL application review, the staff will evaluate the full description of the IST program for pumps, valves, and dynamic restraints provided by the COL applicant to supplement the program description provided in the FSAR. At the U.S. EPR DCWG meeting on March 4, 2009, the applicant stated that its FSAR would fully describe the IST program for the U.S. EPR. The applicant indicated that a COL applicant referencing the U.S. EPR certified design will incorporate by reference the IST program description in the FSAR and supplement those provisions with any plant-specific information to provide a full description of the IST program in accordance with NRC guidance in SECY-05-0197 and RG 1.206. As part of the review of the design certification application, the staff reviewed the description of the IST program in the FSAR for design aspects of the program including accessibility for the performance of IST activities, as well as to confirm that the description of the IST program will be acceptable for incorporation by reference by a COL applicant in its FSAR in support of a COL application.

The design certification application states that the IST of safety-related pumps, valves and snubbers will be performed in accordance with 10 CFR 50.55a(f), the 2004 edition of the ASME OM Code, and the guidance in RG 1.192 and NUREG-1482, Revision 1. As identified in COL Information Item 3.9-13, a COL applicant that references the U.S. EPR design will identify the implementation milestones and applicable ASME OM Code for the preservice and inservice examination and testing programs. These programs must be consistent 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. The ASME OM Code, 2004 Edition selected by the design certification applicant to describe the IST program for the U.S. EPR design certification application has been incorporated by reference in 10 CFR 50.55a, and the proposed update schedule specified in the COL information item conforms to 10 CFR 50.55a(f). Therefore, these U.S. EPR FSAR provisions are acceptable to the staff for the U.S. EPR design certification application.

In regard to the reference to NUREG-1482, Revision 1, the staff notes that there are differences between the IST program documentation specified in NUREG-1482, Section 2.4 and the information provided in FSAR Tier 2, Tables 3.9.6-1 and 3.9.6-2 (e.g., piping and instrument diagram number, drawing coordinates, and valve size are not specified in the U.S.EPR FSAR tables). The staff has determined that the IST tables in the FSAR are sufficient to describe the IST program in support of the design certification application. The staff will review the development of the IST program by a COL licensee as part of future inspection activities.

The staff's review of the descriptions of the individual portions of the IST program for the U.S. EPR is discussed in the following subsections of this SER section.

3.9.6.4.2.1 *Inservice Testing Program for Pumps*

In FSAR Tier 2, Section 3.9.6.2, "Inservice Testing Program for Pumps," the applicant describes the IST program for safety-related pumps for the U.S. EPR. FSAR Tier 2, Table 3.9.6-1, "Inservice Pump Testing Program Requirements," identifies the pumps within the scope of the U.S. EPR IST program, pump identification number, function description, pump type, ASME Code Class, ASME OM Code Group, and the testing provisions and frequency.

The staff reviewed FSAR Tier 2, Section 3.9.6.2 and Table 3.9.6-1 to determine whether the IST program would satisfy the NRC regulations when developed according to the description in the FSAR. In particular, the staff finds the description of the IST program for pumps provided in FSAR Tier 2, Section 3.9.6.2 provides sufficient information to support a determination that the IST program, if properly implemented, will comply with the pump testing provisions contained in Subsections ISTA and ISTB of the 2004 edition of the ASME OM Code. The staff also determined from its review of the IST program description that the FSAR does not specify exceptions to the pump testing requirements in the 2004 edition of the OM Code. In addition, the IST program for the U.S. EPR, described in FSAR Tier 2, Section 3.9.6.1, provides for pump testing over the full range of system differential pressures, flowrates, temperatures, and available voltages (as applicable), from normal operating to design-basis conditions and considers degraded flow that may occur during post-accident conditions.

Based on its review, the staff finds the description of the pump IST program in the FSAR that will apply the 2004 edition of the ASME OM Code incorporated by reference in NRC regulations to be acceptable for the design certification application. A COL applicant that references the U.S. EPR design will need to identify any additional site-specific pumps (i.e., beyond those identified in FSAR Tier 2, Table 3.9.6-1) to be included within the scope of the IST program. This is Combined License Information Item 3.9-8. As required by 10 CFR 52.79(a)(11), a COL applicant that references the U.S. EPR design will also need to describe the implementation of the IST program in this regard.

3.9.6.4.2.2 *Inservice Testing Program for Valves*

In FSAR Tier 2, Section 3.9.6.3, “Inservice Testing Program for Valves,” the applicant describes an IST program for safety-related valves in support of the U.S. EPR design certification. FSAR Tier 2, Table 3.9.6-2, “Inservice Valve Testing Program Requirements,” identifies the valves within the scope of the U.S. EPR IST program, the valve identification number, valve function, valve and actuator type, ASME Code Class, ASME OM Code Category, active or passive function, safety position, and the testing provisions and frequency.

The staff reviewed the IST program description in comparison to the valve testing provisions in the 2004 edition of the ASME OM Code. The staff determined from its review of the valve IST program description that the U.S. EPR FSAR does not specify exceptions to the valve testing requirements in the ASME OM Code, but does describe the use of ASME OM Code Cases discussed below. In addition, the valve IST program described in FSAR Tier 2, Section 3.9.6.1 provides for valve testing over the full range of system differential pressures, flowrates, temperatures, and available voltages (as applicable), from normal operating to design-basis conditions and considers degraded flow that may occur during post-accident conditions.

As a result of its review of the IST program for valves provided in the application, the staff requested additional information in RAI 49, Question 03.09.06-5 as follows:

- The staff requested that the applicant verify that applicable air release and vacuum breaker valves have a stroke test frequency of 2 years as required by ASME OM Code Subsection ISTC-5220. In a June 11, 2009, response to RAI 49, Question 03.09.06-5, the applicant indicated its plan to adjust the test frequency for vacuum breakers listed in FSAR Tier 2, Table 3.9.6-2 to 2 years. This planned correction to the IST table complies with the ASME OM Code and is acceptable to the staff. **RAI 49, Question 03.09.06-5 is being tracked as a confirmatory item**.

- The staff requested that the applicant address the need for leak testing in each direction of the main steam isolation valves (MSIVs). In a June 11, 2009, response to RAI 49, Question 03.09.06-5, the applicant indicated that failure of the MSIVs to isolate in the reverse flow direction does not result in, or increase the severity of, any credible event. The applicant stated that the MSIVs are not required to isolate in the reverse flow direction, and they are leak tested only in the forward flow direction. The applicant's plan for MSIV testing complies with the requirements of the ASME OM Code, Subsection ISTC-3600, and is therefore acceptable.

- The staff noted that the safety injection system diagram (FSAR Tier 2, Figure 6.3-3) shows several POVs that should be included in the IST program. In a June 11, 2009, response to RAI 49, Question 03.09.06-5, the applicant stated that the valves in this system will be added to FSAR Tier 2, Table 3.9.6-2. This planned correction to the IST table is acceptable to the staff. **RAI 49, Question 03.09.06-5 is being tracked as a confirmatory item**.

- The staff requested that the applicant explain the basis for several valves in the IST table that had a passive designation, which appeared to have both open and closed safety positions. In a June 11, 2009, response to RAI 49, Question 03.09.06-5, the applicant explained the basis for considering the cross-connect isolation valves to be passive valves. In particular, these valves do not receive a safety injection signal with open or closed positions. Further, they are only open when maintenance on their train is necessary with their electrical circuit breakers racked out in the open position. The applicant planned to change the designation of other valves to indicate that they have an active safety function. This clarification of the valve designation is acceptable to the staff. **RAI 49, Question 03.09.06-5 is being tracked as a confirmatory item**.

- The staff requested that the applicant clarify the IST table to indicate that all POVs requiring an exercise test will also require a stroke time test (ISTC-5113). In a June 11, 2009 response to RAI 49, Question 03.09.06-5, the applicant indicated that measuring the stroke time for these valves is performed in conjunction with a valve exercise inservice test. The applicant plans to revise the FSAR to indicate that measuring the stroke time for valves is performed in conjunction with a valve exercise inservice test. This planned revision to the FSAR will comply with the ASME OM Code and, therefore, is acceptable to the staff. **RAI 49, Question 03.09.06-5 is being tracked as a confirmatory item**.

- The staff requested that the applicant clarify the IST table to indicate that ASME OM Code Section ISTC-3560 requires the performance of fail-safe testing for applicable valves. In a June 11, 2009 response to RAI 49, Question 03.09.06-5,, the applicant explained that a successful exercise test satisfies a valve's fail-safe testing requirements. The applicant plans to revise the FSAR Tier 2, Table 3.9.6-2 to indicate that "[t]he switch for a fail-safe valve functions by interrupting (de-energizing) the electrical or pneumatic actuating force for the valve whenever the switch is moved to the fail-safe position. Therefore, this normal valve operation demonstrates the valve's fail-safe capability, which is verified during valve exercise testing by remote position indication. Since a successful exercise test satisfies a valve's fail-safe testing requirements, a separate test for fail-safe capability is not required and is not specified in this table." This planned revision to the FSAR will comply with the ASME OM Code and, therefore, is acceptable to the staff. **RAI 49, Question 03.09.06-5 is being tracked as a confirmatory item**.

In the following paragraphs, the staff identifies open items from its review of specific aspects of the description of the IST program for valves provided in U.S. FSAR Tier 2, Section 3.9.6.3. In light of these open items, the staff is not currently able to reach a finding on the compliance of the valve IST program description with NRC regulations.

A COL applicant that references the U.S. EPR design will identify any additional site-specific valves (i.e., beyond those identified in FSAR Tier 2, Table 3.9.6-2) to be included within the scope of the IST program. Valve test procedures and schedules will be included in the test plan which is provided by the COL applicant following the start of construction and prior to performing the tests. This is Combined License Information Item 3.9-6. As required by 10 CFR 52.79(a)(11), a COL applicant that references the U.S. EPR design will also need to describe the implementation of the IST program in this regard.

Inservice Testing Program for Motor-Operated Valves

In the past, nuclear power plant operating experience and NRC and industry research programs revealed significant weaknesses in MOV design, inservice testing, and maintenance that undermined the capability of MOVs to perform their applicable design-basis safety functions. In response to the nuclear power plant operating experience and valve research programs, the NRC issued GL 89-10, GL 96-05, and numerous additional generic communications to alert nuclear power plant licensees to the MOV issues and to request that licensees verify initial and periodically that MOVs are capable of performing their safety functions. In light of the weakness in the IST provisions for MOVs in the ASME OM Code, the NRC revised its regulations in 10 CFR 50.55a(b)(3)(ii) to require nuclear power plant licensees to establish a program to ensure that MOVs continue to be capable of performing their design-basis safety functions in addition to satisfying the IST provisions of the ASME OM Code incorporated by reference in 10 CFR 50.55a.

In FSAR Tier 2, Section 3.9.6.3.1, the applicant states that MOV testing will be incorporated into the initial plant startup test program for the U.S. EPR. As described in the FSAR, IST of MOVs relies on diagnostic techniques that assess valve performance under actual loading (i.e., adequate differential pressure and flow conditions to demonstrate that the MOV continues to perform its safety function to open and close, as applicable, during design-basis conditions). In RAI 49, Question 03.09.06-6 and during the public meeting on March 4, 2009, the staff requested that the applicant clarify its MOV testing plans to address lessons learned from nuclear power plant operating experience and valve research programs.

In a June 11, 2009, response to RAI 49, Question 03.09.06-6, the applicant provided an extensive revision planned for FSAR Tier 2, Section 3.9.6.3.1, based on the RAI question and discussions during the March 4, 2009, public meeting. For example, the applicant indicated that the FSAR will be revised to specify that the acceptance criteria for successful completion of the PST and IST of MOVs will include the following:

- Consistent with the safety function, the valve fully opens and/or closes or both with diagnostic equipment indicating hard seat contact.

- The testing demonstrates adequate margin with respect to the design basis, including consideration of diagnostic equipment inaccuracies, degraded voltage, control switch repeatability, load sensitive MOV behavior, and margin for degradation.

- The maximum required 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.

The planned FSAR revision will also specify that the MOV testing program will incorporate the Joint Owners' Group (JOG) MOV Periodic Verification Program (MPR-2524-A) as accepted in the NRC safety evaluation, dated September 25, 2006. In implementing the JOG program, MOVs in the U.S. EPR will be categorized according to their safety significance and risk ranking. The planned FSAR revision will indicate that operability testing relies on non-intrusive diagnostic techniques conducted in either static or dynamic conditions in accordance with the JOG MOV Program. The planned FSAR revision will specify that testing will be performed to confirm that adequate margin exists in MOV capabilities, including verification that the MOV achieves the necessary torque or thrust, as applicable. Additional changes to the FSAR are planned to clarify MOV program attributes, testing of MOVs, frequency for MOV testing, and acceptance criteria for PST and IST of MOVs. Based on its review, the staff has determined that (with the exception of an MOV open item discussed below) these planned revisions to the description of the IST program for MOVs in FSAR Tier 2, Section 3.9.6 incorporate lessons learned from valve operating experience and testing programs. The planned FSAR changes incorporate the guidance provided in RG 1.206, and satisfy the acceptance criteria in SRP Section 3.9.6 for MOV testing programs. **RAI 49, Question 03.09.06-6, which is associated with the above request, is being tracked as a confirmatory item**.

The planned FSAR revision will specify that the IST program for MOVs will comply with the ASME OM Code, as incorporated by reference in 10 CFR 50.55a. As part of the IST program, the planned FSAR revision will specify that ASME OM Code Case OMN-1, "Alternative Rules for Preservice and Inservice Testing of Certain Electric Motor-Operated Valve Assemblies in Light-Water Reactor Power Plants," will be applied as accepted by the staff with conditions in RG 1.192 as an alternative method to MOV stroke-time testing that also satisfies the requirements in 10 CFR 50.55a(b)(3)(ii) for periodic verification of MOV design-basis capability. The staff finds the specification for use of the version of OM Code Case OMN-1 accepted in RG 1.192 to be acceptable as part of the description of the IST program in support of the U.S. EPR design certification application. If a COL applicant plans to use a revision to the ASME OM Code Case OMN-1 not accepted in RG 1.192, the COL applicant must submit a request to apply an alternative to the ASME OM Code. To ensure the planned FSAR revision is incorporated, **RAI 49, Question 03.09.06-6, which is associated with the above request, is being tracked as a confirmatory item**.

FSAR Tier 2, Section 3.9.6.3.1 states that the interval between testing to demonstrate continued design-basis capability does not exceed 5 years or three refueling outages, whichever is longer. However, the JOG MOV programs test frequencies vary from one refueling outage (e.g., for high-risk low-margin MOVs) up to 5 years or three refueling outages, whichever is longer. Test frequency should be established to provide assurance that the MOVs will remain capable of performing their design-basis function until at least the next scheduled test. Test frequencies should be evaluated each refueling outage based on data trends from MOV test results and operating experience. The frequency of MOV testing should be consistent with the JOG MOV program. **RAI 381, Question 03.09.06-17, which is associated with the above request, is being tracked as an open item**.

Inservice Testing Program for Power-Operated Valves Other than MOVs

POVs, other than MOVs, include for example solenoid-operated valves (SOVs), hydraulic-operated valves (HOVs), and air-operated valves (AOVs). The IST program for POVs within the scope of the ASME OM Code at a U.S. EPR nuclear power plant must comply with the requirements of 10 CFR 50.55a and Subsection ISTC of the OM Code as incorporated by reference in 10 CFR 50.55a. The POV IST program should incorporate applicable lessons learned from MOV operating experience and research programs. The NRC issued RIS 2000-03 to discuss the application of lessons learned from MOV operating experience and research programs to POVs with other than motor actuators. For example, RIS 2000-03 includes a list of attributes for a successful POV design capability and long-term periodic verification program. RIS 2000-03 also references the development of a JOG program on AOV periodic verification testing, and NRC comments on that program.

In RAI 49, Question 03.09.06-6 and during the public meeting on March 4, 2009, the staff requested that the applicant clarify its POV testing plans to address lessons learned from MOV operating experience and research programs. In a June 11, 2009, response to RAI 49, Question 03.09.06-6, the applicant provided a planned revision to FSAR Tier 2, Section 3.9.6.3.2, "Inservice Test Program for Power-Operated Valves Other Than MOVs." For example, the planned FSAR revision will specify that the IST program for POVs will be performed in accordance with the ASME OM Code (2004 Edition), as incorporated by reference in 10 CFR 50.55a. The planned FSAR revision will state that the POV IST program will incorporate industry and regulatory experience and operating experience gained through analysis, design, maintenance, and testing of valves. The planned FSAR revision will state that the POV program will incorporate the guidance in RIS 2000-03 that discusses lessons learned from MOV analysis and tests in response to GL 89-10, GL 96-05, and the JOG AOV program. Based on its review, the staff has determined that (with the exception of the AOV open item discussed below) these planned changes to the description of the IST program for POVs in FSAR Tier 2, Section 3.9.6 incorporate lessons learned from valve operating experience and testing programs. **RAI 49, Question 03.09.06-6, which is associated with the above request, is being tracked as a confirmatory item**.

The planned FSAR revision will state that the design-basis capability of active, safety-related POVs will be verified as part of the design process and that, after installation, these POVs will be tested again to ensure valve setup is acceptable to perform the safety functions.. According to the FSAR, these tests will be typically performed under static conditions and are used to document the baseline performance of the valves to support maintenance and trending programs. During these tests, critical parameters will be measured to ensure proper valve setup. Depending on the valve and actuator type, these parameters will include seat load, running torque or thrust, valve travel, actuator spring rate, bench set and regulator supply pressure. Uncertainties associated with measurement equipment and potential degradation mechanisms as well as those affecting both valve function and structural limits will be addressed. Uncertainties will be considered in the specification of acceptable valve setup parameters or in the interpretation of the test results (or a combination of both). The staff has determined these proposed changes to the FSAR adequately incorporate lessons learned from MOV operating experience and research programs. **RAI 49, Question 03.09.06-6, which is associated with the above request, is being tracked as a confirmatory item**.

FSAR Tier 2, Section 3.9.6.3.2 indicates that installed SOVs are tested using Class 1E electrical power supply voltage and current to verify they remain capable of performing their safety functions during design-basis accident conditions. Each SOV is also tested to confirm the valve moves to its energized position and is maintained in that position, and to confirm that the valve moves to the appropriate fail safe position when de-energized. The staff considers this provision for SOV testing to satisfy SRP Section 3.9.6 and to provide reasonable assurance that the testing will verify the capability of SOVs to perform their safety functions.

The planned revision to FSAR Tier 2, Section 3.9.6.3.2 will specify that additional testing, beyond that required by the ASME OM Code, will be performed as part of the AOV program. The planned FSAR revision will state that the U.S. EPR AOV program will include elements of the JOG AOV program. The planned FSAR revision will state that the U.S. EPR AOV program will incorporate the attributes for a successful long-term periodic verification program for POVs as described in RIS 2000-03 by incorporating lessons learned from previous nuclear power plant operations and research programs as they apply to the periodic testing of AOVs and other POVs included in the IST program. Specifically, the planned FSAR revision will state that AOV program will include the following elements:

- Setpoints for AOVs will be defined based on current vendor information or valve qualification diagnostic testing, such that the valve is capable of performing its design-basis functions.

- Periodic static testing will be performed to identify potential degradation, unless those valves are periodically cycled during normal plant operation under conditions that meet or exceed the worst case operating conditions within the licensing basis of the plant for the valve, which would provide adequate periodic demonstration of AOV capability. If necessary based on valve qualification or operating experience, periodic dynamic testing will be performed to re-verify the capability of the valve to perform its safety functions.

- Sufficient diagnostics will be used to collect relevant data (e.g., valve stem thrust and torque, fluid pressure and temperature, stroke time, operating and/or control air pressure, etc.) to verify the valve meets the functional requirements of the qualification specification.

- Test frequency will be specified and evaluated each refueling outage based on data trends as a result of testing. Frequency for periodic testing will be in accordance with the JOG AOV Program Document.

The staff has determined these proposed changes to the FSAR adequately incorporate lessons learned from MOV operating experience and research programs. **RAI 49, Question 03.09.06-6, which is associated with the above request, is being tracked as a confirmatory item**.

As a result of its review of the IST program for valves, in RAI 352, Question 03.09.06-14, the staff requested that the applicant discuss the safety-related function of two component cooling water supply isolation valves and asked whether these valves should be included in the U.S. EPR IST program. In a February 2, 2010, response to RAI 352, Question 03.09.06-14, the applicant described the safety-related function of these valves and indicated that FSAR Tier 2, Table 3.9.6-2 would be revised to include them in the U.S. EPR IST program and, therefore, the staff finds this acceptable. **RAI 352, Question 03.09.06-14 is being tracked as a confirmatory item**.

Based on its review, the staff does not consider the applicant to have fully described the POV program for the U.S. EPR. In particular, the applicant has not described how the POV testing program for the U.S. EPR compares to the JOG AOV Program, how POV functional margin and test frequencies will be determined, and how static or dynamic tests (or both) will be performed to confirm operability and develop the basis for future testing for POVs.

As a result, the staff issued follow-up RAI 381, Question 03.09.06-17, and requested the applicant to revise the U.S. EPR FSAR to (1) reference the NRC comments on the JOG AOV program contained in the NRC letter to the Nuclear Energy Institute (NEI), October 8, 1999, and (2) incorporate into the FSAR additional attributes of a successful POV design capability and long-term periodic verification program as listed in RIS 2000-3. The following program attributes should be included in the description of the IST program for POVs:

1. Valves will be categorized according to their safety significance and risk ranking.

2. Post-maintenance procedures will include appropriate instructions and criteria to ensure baseline testing is re-performed as necessary when maintenance on a valve, valve repair, or replacement has the potential to affect valve functional performance.

3. Procedures and training specific to the AOV program will address lessons learned from other valve programs and documentation from AOV testing, and maintenance records and records from the corrective action program will be retained and periodically evaluated as part of the AOV program.

Finally, the U.S. EPR FSAR should indicate that the attributes of the AOV testing program described above, to the extent that they apply to and can be implemented with respect to other safety-related POVs will be applied to those other POVs. **RAI 381, Question 03.09.06-17, which is associated with the above request, is being tracked as an open item**.

Inservice Testing Program for Check Valves

U.S. EPR FSAR Tier 2, Section 3.9.6.3.3, “Inservice Testing Program for Check Valves,” describes the IST program to be developed at a U.S. EPR nuclear power plant to comply with ASME OM Code (2004 Edition) as incorporated by reference in 10 CFR 50.55a. For example, the FSAR states that check valve testing includes observations of a direct indicator or other positive means, such as changes in system pressure, flowrate, level, temperature, seat leakage, testing, or nonintrusive testing results. The FSAR indicates that acceptance criteria for check valve testing will consider the system design and valve application. The staff has determined that the applicant has fully described a check valve IST program for the U.S. EPR and that the program description complies with the ASME OM Code (2004 Edition) as incorporated by reference in 10 CFR 50.55a and, therefore, is acceptable to the staff.

The ASME OM Code (2004 Edition) requires the design of the U.S. EPR systems to incorporate provisions to permit all safety-related check valves to be tested for performance in both the forward and reverse flow directions. Specifically, the Code states that the necessary valve obturator movement during exercise testing shall be demonstrated by performing both an open and close test. The capability to perform bi-directional flow testing of check valves should be designed into new reactor systems. In RAI 49, Question 03.09.06-7, the staff requested that the applicant specify that the U.S. EPR design incorporates provisions to allow bi-directional flow testing of check valves in accordance with the ASME OM Code. In a June 11, 2009, response to RAI 49, Question 03.09.06-7, the applicant proposed to modify the FSAR to indicate that the

U.S. EPR design incorporates provisions to permit safety-related check valves to be tested for performance in both the forward and reverse flow directions. This planned revision to the FSAR complies with the ASME OM Code and, therefore, is acceptable to the staff. **RAI 49, Question 03.09.06-7 is being tracked as a confirmatory item**.

FSAR Tier 2, Section 3.9.6.3.3 states that, when operating conditions, valve design, valve location, or other considerations prevent direct observation or measurements by use of conventional methods to determine adequate check valve function, diagnostic equipment and nonintrusive techniques will be used to monitor internal conditions. The FSAR indicates that nonintrusive techniques include acoustic, ultrasonic, magnetic, and x-ray technologies that will be used to measure valve operating parameters (e.g., fluid flow, disk position, disk movement, and disk impact forces) and to detect valve degradation. FSAR Tier 2, Section 3.9.6.3 states that the IST program incorporates nonintrusive techniques to periodically assess the degradation and performance of "selected valves." The SRP acceptance criteria for check valves states diagnostic equipment or nonintrusive techniques that monitor internal component conditions or measure such parameters as fluid flow, disk position, disk movement, disk impact forces, leak tightness, leak rates, degradation, and disk stability should be used, if practical, for preoperational testing and later during IST. This SRP acceptance criterion is not limited to selected check valves. Another SRP acceptance criterion for check valves states that nonintrusive (diagnostic) techniques should be used to periodically assess degradation and the performance characteristics of check valves. In RAI 49, Question 03.09.06-8, the staff requested that the applicant discuss the extent to which the U.S. EPR design will use nonintrusive techniques to periodically assess degradation and performance characteristics of check valves. In a June 11, 2009, response to RAI 49, Question 03.09.06-8, the applicant proposed to modify FSAR Tier 2, Section 3.9.6.3 to indicate that the IST program will incorporate nonintrusive techniques to periodically assess the degradation and performance of check valves. This planned revision to the FSAR will satisfy the SRP acceptance criterion and, therefore, is acceptable to the staff. **RAI 49, Question 03.09.06-8 is being tracked as a confirmatory item**.

FSAR Tier 2, Section 3.9.6.3.3 describes the sample disassembly examination program that will group check valves by similar design, application, and service condition. The ASME OM Code requires that the grouping of check valves for the sample disassembly examination program shall be technically justified and shall consider, as a minimum, valve manufacturer, design, service, size, materials of construction, and orientation. In RAI 49, Question 03.09.06-10, the staff requested that the applicant indicate whether the check valve sample disassembly examination program will include the grouping criteria specified in the ASME OM Code. In a June 11, 2009, response to RAI 49, Question 03.09.06-10, the applicant proposed to revise the FSAR to add a reference to ASME OM Code Subsection ISTC-5221 regarding the sample disassembly examination program. The planned FSAR revision will also specify that the sample disassembly examination program will check valves by category of similar design (manufacturer, size, model number and materials), application, and service condition, including valve orientation, and will specify a periodic examination of one valve from each group. This planned revision to the FSAR will describe a check valve sample disassembly examination program that will comply with the ASME OM Code and, therefore, is acceptable to the staff. **RAI 49, Question 03.09.06-10 is being tracked as a confirmatory item**.

Pressure Isolation Valve Leak Testing

FSAR Tier 2, Section 3.9.6.3.4, "Pressure Isolation Valve Leak Testing," defines pressure isolation valves (PIVs) as two normally closed valves in series within the reactor coolant pressure boundary that isolate the reactor coolant system from an attached low-pressure system. The FSAR specifies that PIVs will be classified as IST Category A or A/C in accordance with the provisions of ASME OM Code, Subsection ISTC-1300. The FSAR indicates that PIV seat leakage tests will be conducted in accordance with ASME OM Code, Subsection ISTC-3630. FSAR Tier 2, Table 3.9.6-2 identifies the PIVs for the U.S. EPR with the applicable IST provisions. The staff has determined that the description of the IST program for PIVs in a U.S. EPR provided in FSAR Tier 2, Section 3.9.6.3.4, complies with the PIV testing requirements contained in Subsections ISTA and ISTC of the 2004 Edition of the ASME OM Code. The staff finds this acceptable.

Containment Isolation Valve Leak Testing

FSAR Tier 2, Section 3.9.3.5, "Containment Isolation Valve Leak Testing," specifies that containment isolation valves (CIVs) will be leak tested in accordance with 10 CFR Part 50, Appendix J, "Primary Reactor Containment Leakage Testing for Water-Cooled Power Plants." FSAR Tier 2, Section 6.2.4, "Containment Isolation System," provides a list of CIVs for the U.S. EPR in Table 6.2.4-1, "Containment Isolation Valve and Actuator Data." FSAR Tier 2, Table 3.9.6-2 identifies CIVs with the applicable IST provisions. The staff has determined that the description of the IST program for CIVs in a U.S. EPR provided in FSAR Tier 2, Section 3.9.6.3.5, complies with the CIV testing requirements contained in Subsections ISTA and ISTC of the 2004 Edition of the ASME OM Code. The staff finds this acceptable.

Inservice Testing Program for Safety and Relief Valves

FSAR Tier 2, Section 3.9.6.3.6, "Inservice Testing Program for Safety and Relief Valves," specifies that safety and relief valve tests in a U.S. EPR will be conducted in accordance with Appendix I, "Inservice Testing of Pressure Relief Devices in Light-Water Reactor Nuclear Power Plants," of the ASME OM Code (2004 Edition). FSAR Tier 2, Section 3.9.6.3.6 states that power-operated relief valves subject to the IST program will be tested in accordance with Subsection ISTC-5100 for IST Category B valves and Subsection ISTC-5240 for IST Category C valves. FSAR Tier 2, Table 3.9.6-2 identifies safety and relief valves with their applicable IST provisions. The staff has determined that the description of the IST program for safety and relief valves in FSAR Tier 2, Section 3.9.6.3.6, complies with the safety and relief valve testing requirements contained in Subsections ISTA and ISTC of the 2004 Edition of the ASME OM Code. The staff finds this acceptable.

Inservice Testing Program for Manually Operated Valves

FSAR Tier 2, Section 3.9.6.3 indicates that periodic IST during operation of valves to assess their operational readiness will be performed in accordance with Subsections ISTA and ISTC of the ASME OM Code (2004 Edition). Subsection ISTC-3540 of the ASME OM Code states that manually operated valves shall be full-stroke exercised at least once every 5 years, except where adverse conditions may require the valve to be tested more frequently to ensure operational readiness. Incorporating by reference the IST provisions specified in the ASME OM Code, the NRC regulations in 10 CFR 50.55a(b)(3)(vi) require manual valves to be exercised on a 2-year interval rather the 5-year interval specified in the Code, provided adverse conditions do not require more frequent testing. ASME OM Code, Subsection ISTC-5210 states that if a manual valve fails to exhibit the required change of obturator position, the valve must be immediately declared inoperable. Valves equipped with remote position indication must be tested in accordance with ASME OM Code, Subsection ISTC-3700, which requires that valves with remote position indication shall be observed locally at least once every 2 years to verify that valve operation is accurately indicated. Subsection ISTC-3700 specifies that, where practicable, this local observation should be supplemented by other indications (such as use of flowmeters or other suitable instrumentation) to verify obturator position, but that these observations need not be concurrent. Where local observation is not possible, Subsection ISTC-3700 states that other indications shall be used for verification of valve operation.

FSAR Tier 2, Section 3.9.6.3.7, “Inservice Testing Program for Manually Operated Valves,” states that manual valves will be exercised at least every 2 years. The FSAR also specifies that exercising of a manually operated valve will include a complete cycle from fully open to fully closed. FSAR Tier 2, Table 3.6.9-2, indicates that the position indication verification for manual valves will be performed in accordance with ASME OM Code, Tables ISTC-3500-1 and ISTC-3700. The staff finds this description of the IST program for manual valves to comply with the NRC regulations, and therefore is acceptable.

3.9.6.4.2.3 *Inservice Testing Program for Dynamic Restraints*

Safety-related piping systems subject to dynamic loading will have dynamic restraints (snubbers) installed at locations to accommodate thermal expansion of the piping system. FSAR Tier 2, Section 3.9.6.4, “Inservice Testing Program for Dynamic Restraints,” describes the IST program to be developed for dynamic restraints at a U.S. EPR nuclear power plant. The FSAR specifies that snubbers will be designed to meet the ASME OM Code (2004 Edition). The FSAR states that the design approach for piping systems and supports, including snubber application, is detailed in Topical Report ANP-10264NP-A, Revision 0, November 2008, which has been accepted by the staff in a safety evaluation incorporated into the topical report.

As stated in FSAR Tier 2, Section 3.9.6.4 and Topical Report ANP-10264, snubbers will be procured in accordance with the quality assurance program for design specifications, which contain the following information:

- Applicable Codes and Standards
- Functional Specifications
- Operating Environment (Both Normal and Post Accident)
- Materials (Construction and Maintenance)
- Functional Testing and Certification
- ASME Code, Subsection NF compliance requirements

FSAR Tier 2, Section 3.9.6.4 specifies that a COL applicant that references the U.S. EPR design certification will provide a table identifying the safety-related systems and components that use snubbers in their support systems, including the number of snubbers, type (hydraulic or mechanical), applicable standard, and function (shock, vibration, or dual-purpose snubber). For snubbers identified as either a dual-purpose or vibration arrester type, the FSAR specifies that the COL applicant shall indicate whether the snubber or component was evaluated for fatigue strength. This meets the acceptance criteria of SRP Section 3.9.6. This is Combined License Information Item 3.9-12.

Snubber Installation

The size and location of snubbers in a piping system are determined by pipe stress analyses of thermal and dynamic loading. Snubbers are installed if analysis determines that thermal displacements are large such that reactive loads and stresses are unacceptable if a rigid restraint is used. Topical Report ANP-10264NP-A, Section 6.6, specifies that snubber use in piping system design is minimized due to the need for periodic maintenance and testing, and accessibility considerations. FSAR Tier 2, Section 3.9.6.4.1, “Snubber Installation,” indicates that snubber installation will be verified to be in accordance with installation instructions and drawings, which includes the manufacturer’s recommendations, hot and cold settings, field location and orientation on the pipe, and other applicable location-specific information.

According to the FSAR and Topical Report ANP-10264NP-A, snubber selection will be based on an iterative process that reconciles the necessary restraint stiffness (i.e., spring constant) determined by the analytical piping model with the proposed configuration at the snubber location. The restraint stiffness determined by the piping analysis will be compared to the available stiffness at the snubber location. The available stiffness will be derived from the snubber stiffness, pipe support components (e.g., pipe clamp, pipe extensions), and structural steel. If the spring constants do not agree, additional analysis will be performed to confirm snubber performance under load. This iteration continues until the snubber load capacities and spring constants are reconciled. In RAI 49, Question 03.09.06-11, the staff requested that the applicant discuss how clearances and different snubber activation and release rates are addressed in the U.S. EPR snubber design process.

In a June 11, 2009, response to RAI 49, Question 03.09.06-11, the applicant indicated that the criteria for design of snubbers, including clearances, are described in Topical Report ANP-10264NP-A, Section 6.6, The topical report contains deflection criteria for snubbers supporting Class 1, 2, and 3 piping. If one support in a piping analysis boundary does not meet the deflection criteria, stiffnesses for all supports within the boundary must be calculated and the piping analysis performed again. The applicant stated that inline structural components for the snubber supports are carefully selected to minimize differences in clearances, stiffnesses, activation rates, release rates, and lost motion due to “deadband.” Additionally, snubbers will be certified by the manufacturer to function as stated in the snubber purchase specification. Finally, the applicant stated that snubbers are included in the IST program to confirm operability and correct installation. As discussed earlier in this section, the applicant plans to revise the FSAR to specifically reference ANP-10264NP-A, Section 6.6, with respect to the design of snubbers. **RAI 49, Question 03.09.06-11 is being tracked as a confirmatory item**.

The U.S. EPR design incorporates provisions that allow ready access for maintenance, inspection, and testing of snubbers. Verification of correct snubber installation and operation is included in the initial test program described in FSAR Tier 2, Section 14.2. This program includes visual inspections, hot and cold position measurements, and documentation of thermally induced component movement that occurs during plant startup. This meets the acceptance criteria of SRP Section 3.9.6.

Snubber Examination and Testing

The integrity of a piping system with installed snubbers is dependent on acceptable snubber performance. FSAR Tier 2, Section 3.9.6.4.2, “Snubber Examination and Testing Program,” specifies that snubber PST and IST will be performed in accordance with Subsection ISTD of the ASME OM Code (2004 Edition). The FSAR indicates that the overall PST and IST intervals are defined in the administrative requirements of Subsection ISTA of the ASME OM Code. The FSAR states that specific examination and testing intervals will be established in accordance with Subsection ISTD of the ASME OM Code. The staff review of the description of the snubber examination and testing program in the U.S. EPR FSAR is discussed below.

Visual Examination

FSAR Tier 2, Section 3.9.6.4.2 specifies that snubbers and their attachments will be visually inspected to identify damage that may affect operability, such as leakage, corrosion, or degradation from environmental exposure or operating conditions. The FSAR indicates that visual inspections will be conducted in accordance with VT-3 examinations as defined by ASME B&PV Code, Section XI, “Rules for Inservice Inspection of Nuclear Power Plant Components,” 2004 Edition. As part of a June 11, 2009, response to RAI 49, Question 03.09.06-11, the design certification applicant provided a planned revision to the FSAR to specify that the intervals for visual examination will be in accordance with ASME OM Code Case OMN-13, “Requirements for Extending Snubber Inservice Visual Examination Interval at LWR Power Plants.” In addition, the applicant proposed to revise FSAR Tier 2, Table 5.2-1, “ASME Code Cases,” to add a reference to Code Case OMN-13 regarding the intervals for visual examination of snubbers. The application of Code Case OMN-13 is acceptable to the staff as indicated in RG 1.192, which is incorporated by reference in 10 CFR 50.55a(b)(6). **RAI 49, Question 03.09.06-11 is being tracked as a confirmatory item**.

FSAR Tier 2, Section 3.9.6.4.2 provides a checklist to be used during visual inspections to verify snubber performance. The items inspected will include the following:

- Snubber load, rating, location, orientation, position setting, and configuration (e.g., attachments and extensions) are in accordance with design drawings and specifications.
- Installation records are reviewed to verify that the snubbers are installed according to the design drawings and their specifications properly reflect the design basis.
- Adequate clearance is available for snubber movement.
- Testing systems used for functional testing of snubbers to determine compression loads and spring/hydraulic conditions are identified.

The staff has determined that the visual inspection described by the applicant meets the acceptance criteria of SRP Section 3.9.6, and therefore is acceptable.

Functional Testing

FSAR Tier 2, Section 3.9.6.4.2 specifies that snubber preservice functional testing will be performed prior to initial plant operation. The FSAR allows snubber testing to be performed at the manufacturer’s facility to verify performance prior to installation. The FSAR specifies that inservice functional testing will be completed within test plan intervals specified by the ASME OM Code (2004 Edition). The FSAR specifies that snubbers will be tested in their as-found condition either in place or bench tested with test parameters selected so that snubbers are tested to the fullest extent practicable.

FSAR Tier 2, Section 3.9.4.2 indicates that snubber functional testing will be used to verify the following parameters:

- Activation occurs in tension and compression within the specified velocity or acceleration range.
- Release rate in tension and compression is within the specified range.
- Displacement under continuous load satisfies design parameter values.
- Drag force in tension and compression is within specified limits.

The staff has determined that the functional testing provisions described by the applicant meet the acceptance criteria of SRP Section 3.9.6, and therefore are acceptable.

Unacceptable Snubbers

FSAR Tier 2, Section 3.9.6.4.2 references GL 90-09, “Alternative Requirements for Snubber Visual Inspection Intervals and Corrective Actions,” for determining that a snubber is unacceptable if it fails the acceptance criteria of the visual inspection. The FSAR specifies that an evaluation will be performed to determine the impact the failed snubber has on the system in which it is installed. The FSAR indicates that unacceptable snubbers will be adjusted, repaired, modified, or replaced and then retested. The staff finds the use of GL 90-09 for the evaluation of snubbers to be acceptable.

Repair or Replacement of Snubbers

FSAR Tier 2, Section 3.9.6.4.2 specifies that snubbers maintained or repaired by removing or adjusting a snubber part that can affect performance will be examined and tested in accordance with the applicable Code requirements before being returned to service. The staff finds the FSAR provisions specifying the use of the ASME Code in the repair and replacement of snubbers to be acceptable.

Service Life Monitoring

FSAR Tier 2, Section 3.9.6.4.2 specifies that the service life of snubbers will be evaluated at least once each fuel cycle and adjusted as necessary. The FSAR notes that the service life evaluation will be based on technical data from operational history of representative snubbers that have been in service in the plant or on other service life information. If the evaluation determines that snubber service life will be exceeded before the next scheduled system or plant outage, the FSAR specifies that one of the following actions will be taken:

- The snubber is replaced.
- The snubber is reconditioned.
- A technical justification is documented for extending the service life.

The staff finds the FSAR provisions for the evaluation of the service life of snubbers satisfy the ASME OM Code, and therefore are acceptable.

Summary

The following summarizes the conclusions of the staff's evaluation set forth above:

The applicant plans to revise the FSAR to specifically reference ANP-10264NP-A, Section 6.6, with respect to the design of snubbers. **RAI 49, Question 03.09.06-11 is being tracked as a confirmatory item**.

The proper installation and operation of snubbers will be verified by the applicant using visual inspections, hot and cold position measurements, and observance of thermal movements during plant startup (Initial Test Program, Test Nos. 034 and 165).

The staff finds the description of the applicant's IST program for dynamic restraint to be acceptable because it meets the requirements of the ASME OM Code as incorporated by reference in 10 CFR 50.55a (SRP Section 3.9.6, acceptance criteria 4(A)).

FSAR Tier 2, Section 3.9.6.4.2 states that snubber PST and IST will be performed in accordance with the ASME OM Code, Subsection ISTD. The use of ASME OM Code Subsection ISTD for the IST of snubbers complies with 10 CFR 50.55a(b)(3)(v) and SRP Section 3.9.6, and is, therefore, acceptable to the staff.

FSAR Tier 2, Section 3.9.6.4.2 indicates that the visual examination of snubbers will be performed in accordance with Code Case OMN-13. Use of ASME Code Case OMN-13 has been accepted by the staff in RG 1.192 and is, therefore, acceptable. The applicant plans to revise the FSAR to reference the use of Code Case OMN-13. **RAI 49, Question 03.09.06-11 is being tracked as a confirmatory item**.

3.9.6.4.3 Relief Requests and Alternative Authorizations to ASME OM Code

In FSAR Tier 2, Section 3.9.6.5, "Relief Requests and Alternative Authorizations to the OM Code," the applicant stated that if it is determined that compliance with the requirements of the ASME OM Code is impractical, relief is requested from the Code in accordance with 10 CFR 50.55a. The applicant further stated that these relief requests identify the applicable Code requirements, justify the relief request, and provide alternative testing methods.

The staff finds that submittal of relief requests by the COL applicant when it establishes the Code edition and addenda to be used for the U.S. EPR IST program is appropriate. The applicant does not identify any ASME OM Code requirements that are impractical for the U.S. EPR plant based on the 2004 edition of the OM Code. More definitively, Topical Report ANP-10292, Revision 0, "U.S. EPR Conformance with Standard Review Plan (NUREG-0800)," December 2007, indicates that no relief requests or alternatives to ASME OM Code requirement are needed for the U.S. EPR design.

As discussed in this SER section, the applicant has incorporated ASME OM Code Cases OMN-1 and OMN-13 in its description of the IST program for a U.S. EPR nuclear power plant. In RG 1.192, which is incorporated by reference in 10 CFR 50.55a(b)(6), the staff has accepted the use of the versions of Code Cases OMN-1 and OMN-13 specifically referenced in the U.S. EPR FSAR.

3.9.6.4.4 Technical Specifications

The staff reviewed the IST program description in FSAR Tier 2, Chapter 16, Section 5.5.7, "Inservice Testing Program." The provisions in FSAR Tier 2, Chapter 16, Section 5.5.7 reference the test frequencies in the ASME OM Code. The U.S. EPR technical specifications do not specify the frequency (i.e., in days) for inservice tests listed as being performed weekly, semiannually, and once every 9-month tests, as is indicated in standard technical specifications for other plant designs. Inasmuch as no pumps or valves included in the U.S. EPR IST program are tested at these frequencies, this is acceptable to the staff. The U.S. EPR technical specifications limit the use of Surveillance Requirement (SR) 3.0.2 to normal and accelerated frequencies specified as 2 years or less in the IST program. The staff finds that the technical specifications related to the IST program for the U.S. EPR provide assurance that the necessary quality of SSCs will be maintained, that facility operation will be within applicable safety limits, and that the limiting conditions for operation will be met. Therefore, the IST technical specifications are acceptable.

3.9.6.5 *Combined License Information Items*

Table 3.9.6-1 of this report provides a list of COL Information Items applicable to preservice and inservice testing of pumps, valves, and dynamic restraints with applicable COL Information Item numbers and descriptions from FSAR Tier 2, Table 1.8-2:

Table 3.9.6.5-1 U.S. EPR Combined License Information Items

Item No.	Description	FSAR Tier 2 Section
3.9-6	As identified by the applicant, a COL applicant that references the U.S. EPR design certification will identify any additional site-specific valves in FSAR Tier 2, Table 3.9.6-2 to be included within the scope of the IST program. Valve test procedures and schedules are included in the test plan which is provided by the COL applicant.	3.9.6.3
3.9-7	As identified by the applicant, a COL applicant that references the U.S.EPR design certification will submit the PST program and IST program for pumps, valves, and snubbers as required by 10 CFR 50.55a.	3.9.6

Item No.	Description	FSAR Tier 2 Section
3.9-8	As identified by the applicant, a COL applicant that references the U.S. EPR design certification will identify any additional site-specific pumps in FSAR Tier 2, Table 3.9.6-1 to be included within the scope of the IST program.	3.9.6.2
3.9-12	As identified by the applicant, a COL applicant that references the U.S. EPR design certification will provide a table identifying the safety-related systems and components that use snubbers in their support systems, including the number of snubbers, type (hydraulic or mechanical), applicable standard, and function (shock, vibration, or dual-purpose snubber). For snubbers identified as either a dual-purpose or vibration arrester type, the COL applicant shall indicate whether the snubber or component was evaluated for fatigue strength.	3.9.6.4
3.9-13	As identified by the applicant, a COL applicant that references the U.S. EPR design certification will identify the implementation milestones and applicable ASME Code for the preservice and inservice examination and testing programs. These programs will be consistent 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.	3.9.6

The staff finds the above listing to adequately describe actions necessary for the COL applicant. No additional COL information items need to be included in FSAR Tier 2, Table 1.8-2, for functional design and qualification, preservice, and inservice testing of pumps, valves, and dynamic restraints.

3.9.6.6 *Conclusions*

For the reasons set forth above, the staff concludes that the U.S. EPR design certification application provides assurance that IST provisions of the ASME OM Code referenced in the FSAR can be performed, and that the U.S. EPR systems and components provide access to permit the performance of testing pursuant to 10 CFR 50.55a(f). Where descriptions of the functional design, qualification, and IST programs were provided by the applicant, the staff concludes that those descriptions comply with the applicable NRC regulations, except for the open and confirmatory items discussed above. As part of a COL application review, the NRC will evaluate the full description of the IST program for pumps, valves, and dynamic restraints provided by the COL applicant through incorporation by reference of the U.S. EPR FSAR and additional information to supplement the program description provided in the U.S. EPR FSAR. As required by 10 CFR 52.79(a)(11), a COL applicant that references the U.S. EPR design will also need to describe the implementation of the IST program in this regard.

3.11 Environmental Qualification of Mechanical and Electrical Equipment

3.12 ASME Code Class 1, 2, and 3 Piping Systems, Piping Components, and their Associated Supports

3.13 Threaded Fasteners (ASME Code Class 1, 2, and 3)

3.13.1 Introduction

The purpose of this section is to review and evaluate the adequacy of the applicant's criteria in regard to selection of materials, design, inspection, and testing of its threaded fasteners (i.e., threaded bolts, studs, etc.) prior to initial service and during service. The scope of this review is limited to threaded fasteners in ASME B&P Vessel Code Class 1, 2, or 3 systems.

3.13.2 Summary of Application

FSAR Tier 1: There are no FSAR Tier 1 entries for this area of review.

FSAR Tier 2: The applicant has provided an FSAR Tier 2 description of threaded fasteners in FSAR Tier 2, Section 3.13, "Threaded Fasteners (ASME Code Class 1, 2, and 3)," summarized here in part, as follows:

The application states that the design and analysis of pressure boundary threaded fasteners meets ASME Class 1, 2, and 3 requirements. Class 1 pressure boundary threaded fasteners are designed in accordance with ASME B&PV Code Section III, Subsection NB (including fracture toughness requirements). Class 2 and Class 3 pressure boundary threaded fasteners are designed in accordance with the applicable ASME B&PV Code Section III, Subsection NC and ND requirements. The criteria for selection and testing of bolting material are as specified in FSAR Tier 2, Table 3.13-1, "ASME B&PV Code Section III Criteria for Selection and Testing of Bolted Materials," (same as SRP Table 3.13-1). Materials used for threaded fasteners are selected for their compatibility with the environmental conditions to which they are exposed. The ASME examination categories for inservice inspection of mechanical joints that are secured by threaded fasteners are specified in FSAR Tier 2, Table 3.13-2, "ASME BPV Code Section XI Examination Categories for Inservice Inspections of Mechanical Joints in ASME Code Class 1, 2, and 3 Systems that are Secured by Threaded Fasteners" (same as SRP Table 3.13-2). Material fabrication processes and special controls (e.g., on the use of lubricants) minimize the potential for galvanic corrosion and stress corrosion cracking (SCC).

The application states that the material and testing of the reactor vessel (RV) closure stud bolting conforms to RG 1.65, "Materials and Inspections for Reactor Vessel Closure Studs." The FSAR Tier 2, Section 5.2.3.6, "Threaded Fasteners," further discusses threaded fasteners associated with the reactor coolant pressure boundary.

ITAAC: There are no ITAAC items for this area of review.

3.13.3 Regulatory Basis

The relevant requirements of NRC regulations for this area of review, and the associated acceptance criteria, are given in NUREG-0800, Section 3.13 and are summarized below. Review interfaces with other SRP sections also can be found in NUREG-0800, Section 3.13.

1. 10 CFR Part 50, Appendix A, GDC 1 as it relates to the requirement that structures, systems, and components important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety function to be performed.

2. GDC 4, as it relates to the compatibility of components with environmental conditions.

3. GDC 14, as it relates to the requirement that the reactor coolant pressure boundary be designed, fabricated, erected, and tested in a manner that provides assurance of an extremely low probability of abnormal leakage, rapidly propagating failure, or gross rupture.

4. GDC 30, "Quality of Reactor Coolant Pressure Boundary," as it relates to the requirement that components that are part of the reactor coolant pressure boundary be designed, fabricated, erected, and tested to the highest quality standards practical.

5. GDC 31, "Fracture Prevention of Reactor Coolant Pressure Boundary," as it relates to the requirement that the RCPB be designed with sufficient margin to ensure that when stressed under operating, maintenance, testing, and postulated accident conditions, the boundary behaves in a nonbrittle manner and the probability of rapidly propagating fracture is minimized.

6. 10 CFR Part 50, Appendix B, as it relates to controlling the cleaning of material and equipment to prevent damage or deterioration.

7. 10 CFR Part 50, Appendix G, "Fracture Toughness Requirements," as it relates to materials testing and acceptance criteria for fracture toughness of reactor pressure boundary components.

8. 10 CFR 50.55a incorporates by reference the design criteria of ASME Code, Section III, Class 1, 2, and 3 components. The selection of materials, design, testing, fabrication, installation, and inspection of threaded fasteners and mechanical joints are acceptable if they meet the criteria of the ASME Code, Section III, Class 1, 2, and 3 components. However, 10 CFR 50.55a(b)(4) permits use of code cases that have been adopted by the staff in RG 1.84, "Design, Fabrication, and Materials Code Case Acceptability, ASME Section III," in lieu of applicable criteria of ASME Code, Section III, Class 1, 2, and 3 components.

Acceptance criteria adequate to meet the above requirements include:

1. RG 1.37, "Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water-Cooled Nuclear Power Plants," as it relates to quality assurance criteria for cleaning fluid systems and associated components that comply with 10 CFR Part 50, Appendix B.

2. RG 1.65 as it relates to selecting materials for and testing of reactor vessel closure studs.

3. RG 1.84 as it relates to ASME Code Cases found by the staff to be acceptable for implementation.

4. NUREG-1339, "Resolution of Generic Safety Issue 29: Bolting Degradation or Failure in Nuclear Power Plants," as it relates to selecting lubricants for use with threaded fasteners.

3.13.4 Technical Evaluation

The staff reviewed the information in FSAR Tier 2, Section 3.13, in accordance with the guidance provided in SRP Section 3.13. The review was performed in order to determine the adequacy of threaded fasteners in ASME Class 1, 2, or 3 systems for material selection; mechanical testing, special process and controls; fracture toughness requirements for ferritic materials; fabrication inspection; quality records; and preservice and inservice inspection requirements. The staff also reviewed the COL information items associated with this section. This section does not address structural bolting. The staff review for structural bolting is documented in Section 3.8 of this report. The staff evaluation for ASME Code Class 1, 2, and 3 threaded fasteners is as follows:

Material Selection

FSAR Tier 2, Section 3.13.1.1 and FSAR Tier 2, Table 3.13-1 provide material selection criteria for threaded fasteners in ASME Class 1, 2, and 3 systems. Material selection will be in accordance with ASME Code, Section III, NCA-1220 and NB-2128 for Class 1 fasteners, NCA-1220 and NC-2128 for Class 2 fasteners, and NCA-1220 and ND-2128 for Class 3 fasteners. Also, materials used in ASME Class 1, 2, and 3 threaded fasteners are selected for their compatibility with the environmental conditions and only proven materials for the specific application and environment are used after evaluating the potential for degradation, including galvanic corrosion and stress cracking corrosion.

The reactor vessel closure studs specified by the applicant are SA-540, Grade 24V Class 3. This material is approved by ASME Code, Section III, NB-2128 for use as RV closure studs. 10 CFR 50.55a incorporates by reference ASME code Section III without limitations or modifications to the RV closure studs materials. The applicant also states that the reactor vessel studs will conform to the material recommendations of RG 1.65 which provides guidance in selecting reactor vessel closure stud material and properties.

The staff finds the material selection for fasteners in ASME Class 1, 2, and 3 systems, including reactor vessel closure studs, to be acceptable, because the applicant has demonstrated compliance with ASME Code, Section III and follows the guidance in RG 1.65.

Mechanical Testing (Coupons)

FSAR Tier 2, Section 3.13.1.2, "Special Materials Fabrication Processes and Special Controls," and FSAR Tier 2, Table 3.13-1 provide heat treatment and tensile test coupon preparation criteria for threaded fasteners fabricated from ferritic materials (i.e., carbon steel, low-alloy steel, quenched and tempered steel). The applicant specified the appropriate test coupon preparation criteria for ASME Class 1, 2, and 3 threaded fasteners. FSAR Tier 2, Table 3.13-1 identifies the appropriate sections of the ASME Code relative to heat treatment criteria and test coupon preparation criteria for ferritic steel materials. As stated in the ASME Code, the applicant must apply criteria of ASME Code, Section III, Subparagraphs NB-2200, NC-2200, or ND-2200 rather than the criteria of the material specification applicable to the mechanical testing if there is a conflict between the two sets of criteria.

The staff finds the treatment and tensile test coupon preparation criteria for fasteners in ASME Class 1, 2, and 3 systems to be acceptable, because the applicant has demonstrated compliance with ASME Code, Section III.

Special Processes and Controls

FSAR Tier 2, Section 3.13.1.2 provides criteria for special processes and controls for threaded fasteners. Special processes and controls for threaded fasteners are acceptable if the regulatory guidance and industry experience are appropriately specified by the applicant. Special process and controls include surface treatments: Lubricants, sealants, cleaners, and material compatibility to preclude galvanic corrosion.

In an October 10, 2008, response to RAI 99, Question 03.13-2, the applicant provided the following additional information for the use of coatings for bolting applications:

> Surface treatments, coatings, and plating are not an effective solution to corrosion of ferritic bolting materials related to exposure of the material to hot, concentrated boric acid associated with leakage which concentrates the dilute acid to much higher levels. As addressed in RG 1.65, the reactor pressure vessel (RPV) studs are provided with a manganese phosphate surface treatment as an additional corrosion inhibitor. Furthermore, as discussed in FSAR Tier 2, Section 5.3.1.7, corrosion protection is provided by the reactor closure studs not being exposed to borated water (i.e., the studs are removed and stud holes plugged before removing the RPV head for refueling). The U.S. EPR design does not include metal-plated coatings.

Lubricants for the U.S. EPR are selected in accordance with the guidance provided in NUREG-1339. Lubricants and sealants selected for threaded fasteners are based on experience that they do not cause or accelerate corrosion of the fastener. In an October 10, 2008, response to RAI 99, Question 03.13-3, the applicant provided the following additional information for the use of lubricants for bolting applications:

> Based on operating experience of current operating plants (e.g., NRC Bulletin 82-02) and as discussed in NUREG-1339, molybdenum disulfide (MoS_2) lubricants have been identified as a potential contributor to stress corrosion cracking failures of bolting in operating plants. Therefore, these lubricants are not recommended for use in U.S. EPR bolting applications.
>
> Lubricants used for ASME Class 1, 2, and 3 (nuclear safety-related) applications are graphite nickel-based materials that have been used satisfactorily in current operating plants (e.g., Fel-Pro N5000, Neolube, Nuclear Grade Never-Seize). These materials have provided acceptable lubrication for bolted connections while maintaining stability at elevated operating temperatures. Additionally, these materials provide radiation resistance inside containment in high radiation environments.

Teflon-based lubricants exhibit acceptable chemical resistance and stability at elevated operating temperatures; however, they have poor resistance to radiation. In addition, teflon is not acceptable for use in the primary systems due to its high fluorine content. It is recommended in EPRI NP-5769-V2 (Page 1-12) (as referenced in NUREG-1339) that a single lubricant be used for bolting materials to facilitate control and minimize potential use of the incorrect lubricant in specific applications. As the use of teflon is restricted for use in primary systems and inside containment, the graphite-nickel based materials are preferred for bolting applications.

Final selection of lubricants will be based on meeting qualification requirements specified in FSAR Tier 2, Section 3.11 for nonmetallic materials, as required.

The guidance in RG 1.37 provides quality assurance criteria for cleaning fluid systems and associated components to minimize the probability that detrimental materials (contaminates) will come in contact with and cause detrimental effects on component materials. The cleaning criteria in RG 1.37 are applied to threaded fasteners, so that contaminants will not damage or deteriorate the materials, alter their properties, accelerate effects associated with aging, or increase the susceptibility to failure mechanisms such as stress corrosion cracking. The applicant states conformance to the guidance in RG 1.37 for cleaning of threaded fasteners.

The staff finds special processes and controls, including surface treatments and lubricants, for fasteners in ASME Class 1, 2, and 3 systems to be acceptable, because the applicant has conformed to the appropriate regulatory guidance and taken into account industry experience.

Fracture Toughness Requirements for Ferritic Materials

The fracture toughness of ferritic bolts, studs, and nuts (i.e., made from either low-alloy steel or carbon steel materials) is acceptable if the appropriate ASME Code, Section III criteria are specified by the applicant for ASME Code Class 1, 2, and 3 systems. Ferritic bolts, studs, and nuts (i.e., bolts, studs, and nuts made from either low-alloy steel or carbon steel materials) used in RCPB applications must meet the requirements contained in 10 CFR Part 50, Appendix G.

FSAR Tier 2, Section 3.13.1.3 and FSAR Tier 2, Table 3.13-1 provide criteria for fracture toughness for threaded fasteners made from ferritic materials. The applicant states that ASME Code Class 1 fasteners meet the fracture toughness requirements of ASME, Section III, NB-2300 for materials to be impact tested, types of impact tests, test coupons, acceptance standards number of impact tests, retesting, and calibration of equipment and 10 CFR Part 50, Appendix G for additional fracture toughness material and testing requirements. The ASME Code Class 2 and 3 fasteners meet the requirements of ASME, Section III, NC-2300 and ND-2300, respectively for materials to be impact tested, types of impact tests, test coupons, acceptance standards number of impact tests, retesting, and calibration of equipment. The reactor vessel closure studs also conform to material and inspection guidance in RG 1.65 for fracture toughness. Therefore, the applicant meets the regulatory requirements for fracture toughness of Code Class 1, 2, and 3 ferritic fasteners.

The staff finds fracture toughness for ferritic threaded fasteners in ASME Class 1, 2, and 3 systems to be acceptable, because the applicant has demonstrated compliance with ASME Code, Section III and 10 CFR Part 50, Appendix G, and conforms to RG 1.65.

Fabrication Inspection

Fabrication inspection (examination) criteria for threaded fasteners are acceptable if ASME Code, Section III criteria is appropriately specified for ASME Class 1, 2 and 3 fasteners. The fabrication inspections include visual, magnetic particle, liquid penetrant, and ultrasonic examinations performed during various stages of fabrication of ensure integrity of the fasteners.

In FSAR Tier 2, Section 3.13.1.2 and FSAR Tier 2, Table 3.13-1 the applicant specifies the use of ASME Code, Section III, NB-2580 for Class 1 fasteners, NC-2580 for Class 2 fasteners, and ND-2580 for Class 3 fasteners, for inspection of threaded fasteners during the fabrication process.

The staff finds the fabrication inspection for threaded fasteners in ASME Class 1, 2, and 3 systems to be acceptable, because the applicant has demonstrated compliance with ASME Code, Section III.

Quality Records Certified Material Test Reports (CMTRs)

Quality records for threaded fasteners used in ASME Code Class 1, 2, and 3 systems are acceptable if the applicant complies with 10 CFR 50.71, “Maintenance of records, making of reports,” to maintain records and reports for ASME Code Class 1, 2, and 3 fasteners.

FSAR Tier 2, Section 3.13.1.5, “Certified Material Test Reports,” and FSAR Tier 2, Table 3.13-1 specifies that pressure-retaining Class 1, 2, and 3 bolts and studs shall comply with the record keeping requirements of 10 CFR 50.71. In addition, FSAR Tier 2, Section 3.13.1.5 specifies the following for ASME Code Class 1, 2, and 3 fasteners: (1) pressure retaining fasteners shall comply with the CMTRs requirements of ASME Code, Section III, NB-2130 for Class 1, NC-2130 for Class 2, ND-2130 for Class 3; (2) material identification is required per ASME Code, Section III NB-2150 for Class 1, NC-2150 for Class 2, and ND-2150 for Class 3, and; (3) the results of material chemistry tests (i.e., alloying elements) and physical property tests will be documented in applicable CMTRs.

The staff finds the quality records for threaded fasteners in ASME Class 1, 2, and 3 systems to be acceptable, because the applicant has demonstrated compliance with 10 CFR 50.71 and Section III of the ASME Code related to documentation of tests in CMTRs.

Preservice and Inservice Inspection Requirements for Threaded Fasteners

Preservice and inservice inspections for ASME Code Class 1, 2, and 3 fasteners are acceptable if the applicant specifies the applicable inspection criteria in ASME Code, Section XI. These are periodic inspections of various components (including pressure retaining fasteners) performed during the operational life of the plant.

FSAR Tier 2, Section 3.13.1.4, “Pre-Service Inspection Requirements,” provides criteria for preservice inspections that are to be completed prior to initial plant startup. For preservice inspection, the applicant specifies ASME Code, Section XI, IWB-2200 for Class 1 threaded fasteners; ASME Code, Section XI, IWC-2200 for Class 2 threaded fasteners; and ASME Code, Section XI, IWD-2200 for Class 3 threaded fasteners.

FSAR Tier 2, Section 3.13.2 and FSAR Tier 2, Table 3.13-2 provide criteria for inservice inspections which include inspection of threaded fasteners during system pressure tests. For inservice inspections, the applicant specifies ASME Code, Section XI, IWC-2500 for Class 2 threaded fasteners; and ASME Code, Section XI, IWD-2500 for Class 3 threaded fasteners. In an October 10, 2008, response to RAI 99, Question 03.13-4, the applicant provided the following additional information to address compliance with the requirements of 10 CFR 50.55a(b)(2)(xxvii) for visual examination of certain insulated bolting or studs during system pressure testing:

> FSAR Tier 2, Section 3.13.2 states that inservice inspection of threaded fasteners is performed in accordance with the applicable edition and addenda of ASME Section XI as required by 10 CFR 50.55a, which includes the modifications and limitations of 10 CFR 50.55a(b)(2) for use of specific editions/addenda of ASME Section XI. 10 CFR 50.55a(b)(2)(xxvii) specifies that insulation must be removed from mechanical joints that use certain stud or bolting materials in systems containing borated water when performing the VT-2 examinations for system pressure testing when using editions/addenda of ASME Section XI later than 2002 Addenda.
>
> Additionally, FSAR, Tier 2, Section 5.2.4 and Section 6.6 state that the site-specific preservice and inservice programs of a COL applicant referencing the U.S. EPR design certification will identify the applicable edition and addenda of ASME Section XI. The applicable edition and addenda of Section XI for the inservice inspection program of Class 1, 2, and 3 threaded fasteners will also be specified by the COL applicant.
>
> The COL Information Item in FSAR Tier 2, Section 3.13.2 and Table 1.8-2, will be revised to indicate that the COL applicant is responsible for identifying the applicable edition and addenda of ASME Section XI and for determining compliance with the requirements of 10 CFR 50.55a(b)(2)(xxvii).

The staff finds the preservice and inservice inspections for threaded fasteners in ASME Class 1, 2, and 3 systems to be acceptable, because the applicant has described its methods for complying with the inservice inspection requirements of 10 CFR 50.55a and ASME Code, Section XI.

<u>Inspections, Tests, Analyses, and Acceptance Criteria</u>

There are no ITAAC associated with this FSAR Tier 2 section for threaded fasteners in ASME Class 1, 2, or 3 systems.

<u>COL Information Items</u>

FSAR Tier 2, Table 1.8-2 Information Item 3.13-1 states that a COL applicant referencing the U.S. EPR design will submit the inservice inspection plan for ASME Class 1, Class 2, and Class 3 threaded fasteners to the NRC prior to performing the first inspection. Threaded fasteners are a component covered in preservice and inservice inspection operational programs in FSAR Tier 2, Sections 5.2.4, “Inservice Inspection and Testing of the RCPB,” and FSAR Tier 2, Section 6.6, “Inservice Inspection of Class 2 and 3 Components.” The staff has confirmed that Revision 1 of FSAR, dated May 29, 2009, revised the COL information item as indicated in the applicant’s response to RAI 99, Question 03.13-4. Accordingly, the staff finds that the applicant has adequately addressed this issue and, therefore, it is resolved.

3.13.5 Combined License Information Items

Table 3.13-1 of this report provides a list of threaded fastener related COL Information Item numbers and descriptions from FSAR Tier 2, Table 1.8-2:

Table 3.9.6.6-1 U.S. EPR Combined License Information Items

Item No.	Description	FSAR Tier 2 Section
3.13-1	A COL applicant referencing the U.S. EPR design certification will submit the inservice inspection plan for ASME Code Class 1, Class 2, and Class 3 threaded fasteners to the NRC prior to performing the first inspection. The program will identify the applicable edition and addenda of ASME Section XI and ensure compliance with the requirements of 10 CFR 50.55a(b)(2)(xxvii).	3.13.2

The staff finds the above listing to be complete. Also, the list adequately describes actions necessary for the COL applicant. No additional COL information items need to be included in FSAR Tier 2, Table 1.8-2 for threaded fastener considerations.

3.13.6 Conclusions

Based on the above evaluation, the staff finds that the applicant has provided reasonable assurance that threaded fasteners in ASME Class 1, 2, or 3 systems meet the acceptance criteria for selection of materials, design, inspection, and testing prior to initial service and during service. Therefore, the staff finds that FSAR Tier 2, Section 3.13 complies with the requirements of GDC 1, GDC 4, GDC 14, GDC 30, and GDC 31 of Appendix A to 10 CFR Part 50; Appendix B and Appendix G to 10 CFR Part 50; and 10 CFR 50.55a, and is therefore acceptable.