- 10 CFR 52.47(b)(1), “Contents of Applications; Technical Information,” as it relates to the requirement that a design certification application (DCA) 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 DC is built and will operate in accordance with the DC, the provisions of the Atomic Energy Act of 1954, and NRC regulations.

The acceptance criteria adequate to meet the above requirements are listed in SRP 3.3.1, along with the review interfaces with other SRP sections.

3.3.1.4 Technical Evaluation

3.3.1.4.1 *Applicable Wind Design Parameters*

Safety-related structures need to meet GDC 2, which requires that they be designed to withstand the effects of tornadoes and hurricanes, among other natural phenomena hazards, without losing the capability to perform their safety functions. This includes consideration of the most severe of natural phenomena that have been historically reported for a site and appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena.

The DCD Tier 2, Section 3.3, “Wind and Tornado Loadings,” states that all seismic Category I and II SSCs, except those not exposed to wind, are designed for wind and tornado/hurricane loadings (addressed in Sections 3.8.1 and 3.8.4, of this SER on loads and load combinations for concrete containment and other seismic Category I structures, respectively). DCD Tier 2, Section 3.3.1, states that the wind speed used as a basis for determining the wind design load is the wind speed for a 3 second gust measured at 10 m (33 ft.) above the ground. The design wind speed is 64.8 m/s (145 mph) under open terrain conditions. The staff compared the wind speed with the information presented in Figure 6-1 of the American Society of Civil Engineers/Structural Engineering Institute (ASCE/SEI) standard 7-05, “Minimum Design Loads for Buildings and Other Structures,” and confirmed that the design wind speed specified by the applicant represents the highest wind speed for the United States (U.S.) at the prescribed height and open terrain conditions (Exposure Category C), with the exception of the southern tip of Florida and the eastern tip of Louisiana.

The SRP Section 3.3.1 and Section 3.3.2, “Tornado Loadings,” recommend the use of ASCE/SEI 7-05 to transform wind speed into velocity pressure and the design wind loads; therefore, the applicant’s use of this ASCE/SEI standard is acceptable.

Based on ASCE/SEI 7-05, Table 1-1, “Occupancy Category of Buildings and Other Structures for Flood, Wind, Snow, Earthquake, and Ice,” the applicant categorized the occupancy of seismic Category I SSCs as Occupancy Category IV structures. The annual probability of exceedance of Occupancy Category IV is 0.01 (mean reoccurrence interval of 100 years). Therefore, the application of the importance factor of 1.15 (taken from Table 6-1, “Importance Factor I” (wind loads) of ASCE/~~SEI 7 05~~) to adjust the velocity pressure is consistent with the guidance in SRP Section 2.3.1, “Regional Climatology.”

SEI 7-05

Table 3.4.1 Combined License Information Items

Item No.	Description
COL 3.4(3)	The COL applicant is to establish procedures and programmatic controls to ensure the availability of the floor drainage.
COL 3.4(4)	The COL applicant is to periodically inspect watertight doors and the penetration seals to ensure their functionality.
COL 3.4(5)	The COL applicant is to provide flooding analysis with flood protection and mitigation features from internal flooding for the CCW Heat Exchanger Building and ESW Building.

3.4.1.6 Conclusions

The staff finds the review of the DCD application supported that the APR1400 internal flood protection design acceptable for the reasons set forth above and meets the requirements of GDC 2, GDC 4, and 10 CFR 52.47(a)(25).

As set forth above, the staff found that the ITAAC, Technical Specifications, and COL applicant information Items specified ensure that site-specific information not provided in the DCD is identified and addressed with respect to internal flood protection, and that flood protection features incorporated in the plant design can be properly inspected, tested and operated in accordance with DCD requirements.

3.4.2 Analysis Procedures

3.4.2.1 Introduction

APR1400

This section reviews the applicant's data on the highest flood and groundwater levels and the analysis procedure used to transform the static and dynamic effects of the waters into effective design loads for use in the design of structures important to safety. In doing so, the staff evaluates the acceptability of the data and processes used to meet the requirements of GDC 2, by which SSC's important to safety must be designed to withstand the effects of the highest probable maximum flood (PMF) and maximum groundwater levels without loss of their capability to perform the safety functions. This section documents the staff's review, evaluation, and findings regarding the procedure for converting the maximum flood water heights to effective applied loads and the analytical procedures to be applied for the evaluation of building components and structures of the ~~AP1000~~ design that are important to safety from the effects of this natural phenomena in combination with other concurrent loads.

3.4.2.2 Summary of Application

DCD Tier 1: The DCD Tier 1 information associated with this section is found in DCD Tier 1, Section 2.1, Section 2.2.1, "Nuclear Island," Section 2.2.2, "Emergency Diesel Generating Building," and Section 2.2.5, "Protection against Hazards," which cover the design basis flood spectral

The APR1400 DCD Tier 2 references draft Revision 4 of SRP 3.7.1, issued in December 2012. The staff review of DCD Tier 2 Section 3.7, follows the guidance provided in the final version SRP 3.7.1, Revision 4, issued in December 2014. The staff recognizes that the NRC issued SRP 3.7.1, Revision 4, less than 6 months prior to the docket date of the APR1400 application in March 2015, and therefore, the applicant is not required under 10 CFR 52.47(a)(9) to evaluate its application against this revision. However, the principal difference between the draft and final versions of SRP 3.7.1, Revision 4, lies in the enhanced guidance on the assessment of power ~~spectra~~ density (PSD) functions of the synthetic acceleration time histories, which are used as seismic input motions to the analyses of the seismic Category I structures.

The staff reviewed DCD Tier 2 Section 3.7.1, and performed an independent analysis (see Section 3.7.1.4.1 below) based on SRP Section 3.7.1, Revision 4, to confirm the applicant's conclusion on the power sufficiency of its synthetic acceleration time histories.

3.7.1.2 Summary of Application

DCD Tier 1: The DCD Tier 1 information associated with this section is found in DCD Tier 1, Section 2.1, "Site Parameters," and DCD Tier 1, Section 2.2, "Structural and System Engineering."

DCD Tier 2: In DCD Tier 2, Section 3.7.1, the applicant provided information on the design ground motion, percentage of critical damping values, and supporting media. The associated seismic design parameters are used in the analyses of seismic Category I SSCs, which are covered by the review under SRP Section 3.7.2, "Seismic System Analysis," and SRP 3.7.3, "Seismic Subsystem Analysis." DCD Tier 2, Section 3.7.1 references Technical Report APR1400-E-S-NR-14001-P, Revision 1, "Seismic Design Bases," dated February 2017 (ADAMS Accession No. ML17094A154), and incorporates by reference Technical Report APR1400-E-S-NR-14004-P, Revision 2, "Evaluation of Effects of HRHF Response Spectra on SSCs," dated February 2017 (ADAMS Accession No. ML17094A116). DCD Tier 2, Appendix 3.7A, "Soil-Structure Interaction Analysis Methodology and Results," and Appendix 3.7B, "Evaluation for High Frequency Seismic Input," provide additional details on the seismic design parameters, as well as seismic analyses pertaining to the staff's review under SRP 3.7.2.

DCD Tier 2 Section 3.7.1 indicates that seismic Category I SSCs are designed for the SSE, in accordance with GDC 2 of Appendix A to 10 CFR Part 50. The OBE for APR1400 is specified at one-third of the SSE, therefore, an explicit analysis and design of the seismic Category I SSCs against the OBE is not necessary, in accordance with Appendix S to 10 CFR Part 50.

DCD Tier 2 Section 3.7.1 describes the design response spectra of the site-independent SSE, that is, the CSDRS, and the corresponding design ground motion time histories that were developed to envelop the CSDRS. The APR1400 CSDRS are specified for 2-, 3-, 4-, 5-, 7-, and 10-percent damping values, as provided in DCD Tier 2 Table 3.7-1. The DCD Tier 2 Section 3.7.1 and APR1400-E-S-NR-14001-P, Revision 0, provide details on the establishment of the CSDRS and the development of the design acceleration time histories. The CSDRS, as shown in DCD Tier 2, Figures 3.7-1 and 3.7-2, for the horizontal and vertical directions are based on the design spectra in RG 1.60, "Design Response Spectra for Seismic Design of

As stated in Section 3.7.3.4.4 of this SER, the staff confirmed that DCD Tier 2, Revision 1, dated March 10, 2017, was revised as committed in the response to RAI 267-8301, Question 03.07.03-2, and the staff considers RAI 267-8301, Question 03.07.03-2, resolved.

3.7.3.4.12 *Seismic Category I Buried Piping, Conduits, and Tunnels*

DCD Tier 2 Section 3.7.3.7, "Buried Seismic Category I Piping, Conduits, and Tunnels," indicates that the seismic analysis of buried seismic Category I piping, conduits, and tunnels is to be performed by the COL applicant in accordance with the following COL information item:

> COL 3.7(6): The COL applicant is to perform seismic analysis of buried seismic Category I ~~piping,~~ conduits, and tunnels.

delete

This DCD section gives a generic description of the methodologies; however, based on COL 3.7(6), the detailed review and evaluation of these items will be performed at the COL stage following SRP Acceptance Criterion 3.7.3.II.12.

DCD Tier 2 Section 3.7.3.7 describes the general methodologies for the seismic analysis of seismic Category I buried piping, conduits, and tunnels. It recognizes that various seismic waves propagating through the surrounding soil and the dynamic differential movements of the buildings create a very complex seismic loading condition for the buried SSCs. ASCE 4-98, "Seismic Analysis of Safety Related Nuclear Structures and Commentary," is referenced for the calculation of the seismic induced upper bound strains and stresses. This DCD section indicates that the strain of the buried structure is assumed to be the same as that of the surrounding soil, and the relative deformation between anchor points and the adjacent soil is considered in the design using the SRSS method for the three orthogonal stresses associated with the relative displacements. The resistance effect of the surrounding soil, the differential movement of the anchors, the shape or curvature changes of the bent parts, underground water effect, and lateral dynamic soil pressure are considered following various ASCE 4-98 procedures. The DCD also indicates that the buried structure can be modeled as beam elements supported by an elastic foundation representing soil stiffness. The generic description in DCD Tier 2 Section 3.7.3.7 is consistent with SRP Acceptance Criterion 3.7.3.II.12. In particular, SRP Acceptance Criterion 3.7.3.II.12 states that the actual methods used to determine the design parameters associated with seismically induced transient relative deformations are reviewed and accepted on a case by case basis. Consistent with this guidance, the detailed staff evaluation of seismic Category I buried piping, conduits, and tunnels will be performed in the review of COL applications.

3.7.3.4.13 *Methods for Seismic Analysis of Seismic Category I Concrete Dams*

DCD Tier 2 Section 3.7.3.8, "Methods for Seismic Analysis of Category I Concrete Dams," indicates that the seismic analysis of any site specific seismic Category I concrete dams will be performed by the COL applicant in accordance with the following COL information item:

> COL 3.7(5): ~~The COL applicant is to perform any site-specific seismic design for dams that is required.~~

The COL applicant is to perform seismic analysis for any site-specific seismic Category I dams, if necessary.

in a structure that can yield highly correlated input motions at the base of the tanks. Therefore, on October 22, 2015, the staff issued RAI 267-8301, Question 03.07.03-1 (ADAMS Accession No. ML15295A261), asking the applicant to provide a technical basis for considering only the larger of the two horizontal input motions in the seismic analysis of tanks.

In its response to RAI 267-8301, Question 03.07.03-1, the applicant revised DCD Tier 2 Section 3.7.3.9 to restrict the scope of this DCD section to only cylindrical tanks that are anchored to reinforced concrete pads. With this revision, the staff finds that the use of the larger of the two horizontal earthquake components is acceptable because the vector effect is not considered to be significant for the cylindrical tanks mounted on the ground surface when they are subjected to statistically independent ground motion. The statistical independence of ground motions for CSDRS or HRHF response spectra has been confirmed in SER Section 3.7.1.4.1.

The applicant also revised DCD Tier 2, Section 3.7.3.9, to indicate that the seismic Category I tanks constructed as part of buildings are included in the seismic analysis finite element models. Therefore, the potentially correlated building responses imposed on these tanks as input motions, are directly considered in the seismic analysis. The seismic analysis of seismic Category I structures is described in DCD Tier 2 Section 3.7.2.3, and is evaluated in SER Section 3.7.2.

For seismic Category I tanks installed in the buildings, such as firewater tanks, fuel tanks for the emergency diesel generator, and other mechanical tanks, the applicant included in DCD Tier 2, Section 3.7.3.9, a reference to DCD Tier 2, Section 3.9.2.2.14, "Seismic Analysis for Mechanical Tanks," which is a new DCD section as a result of RAI 267-8301, Question 03.07.03-1. The staff's evaluation of DCD Tier 2 Section 3.9.2.2.14 is found in SER Section 3.9.2.

The staff confirmed that DCD Tier 2, Revision 1, dated March 10, 2017, was revised as committed in the responses to RAI 267-8301, Question 03.07.03-1. Accordingly, the staff considers RAI 267-8301, Question 03.07.031-1, resolved.

3.7.3.5 Combined License Information Items

DCD Tier 2, Revision 1, Section 3.7.3, contains three COL information items pertaining to seismic subsystem analysis. Based on the discussion above, the staff concludes that these three COL information items are acceptable.

The COL applicant is to perform seismic analysis for any site-specific seismic Category I dams, if necessary.

Table 3.7.3 Combined License Information Items

Item No.	Description
COL 3.7(5)	~~The COL applicant is to perform any site-specific seismic design for dams that is required.~~
COL 3.7(6)	The COL applicant is to perform seismic analysis of buried seismic Category I ~~piping,~~ conduits, and tunnels.

delete

The applicant also proposed modifications to the DCD Tier 2 Section 3.7.4.4 to incorporate the RAI response into the DCD. Because the RAI response and proposed DCD modification address the need for procedures for determining if the OBE has been exceeded and for determining the CAV and following applicable NRC guidance, the staff finds the response acceptable and is tracking the inclusion of the proposed modifications as a **Confirmatory Item**.

The applicant specified in DCD Section 3.7.4.6 that the COL applicant is to develop implementation milestones for the seismic instrumentation program as part of COL 3.7(10). This information item ensures that COL applicants have a seismic instrumentation program developed and implemented at the time of startup.

In RAI 4-7830, Question 03.07.04-2, the staff asked the applicant to discuss what DCD provisions are applicable to plant restart in the event of a seismic event.

In its response dated April 13, 2015, (ADAMS Accession No. ML15132A595), the applicant stated that COL applicants are to prepare a procedure for post-shutdown inspection and plant restart due to a seismic event in accordance with RG 1.167 as part of COL 3.7(11).

The applicant also proposed modifications to DCD Tier 2, Section 3.7.4.6, Section 3.7.5, and Table 1.8-2. The staff reviewed the RAI response and the proposed changes to the DCD. The applicant cites applicable regulatory guidance and requires that COL applicants develop procedures for post-earthquake actions in accordance with that guidance. Therefore, the staff finds the applicant's response acceptable, and the staff is tracking the inclusion of the proposed modifications as a **Confirmatory Item**.

The staff notes that there are no ITAAC Items associated with DCD Tier 2 Section 3.7.4.

3.7.4.5 Combined License Information Items

DCD Tier 2, Revision 1, Section 3.7.4, contains the following COL information items. Based on the discussion above, the staff concludes that these COL information items are acceptable.

Table 3.7.4 Combined License Information Items

Item No.	Description
COL 3.7(8)	The COL applicant is to determine whether essentially the same seismic response from a given earthquake is expected at each unit in a multi-unit site or if each unit is to be provided with a separate set of seismic instruments.
COL 3.7(9)	~~The COL applicant is to perform seismic analysis of buried seismic Category I piping, conduits, and tunnels.~~ The COL applicant is to confirm details of the locations of the triaxial time-history accelerographs.
COL 3.7(10)	The COL applicant is to identify implementation milestones for the seismic instrumentation implementation program as discussed in DCD Subsections 3.7.4.1-3.7.4.5.

hardened—consisting of horizontal and inverted U-shaped vertical tendons. The unbonded tendons are placed in steel sheaths embedded in the concrete. The dome is prestressed by horizontal tendons and inverted U-shaped tendons. The horizontal tendons are anchored at three buttresses, equally spaced at 240 degrees apart around the containment wall, bypassing the intermediate buttress. The inverted U shaped tendons run vertically up the RCB cylinder and over the dome, then down to the circular tendon gallery in the basemat slab. The tendon gallery allows for installing and servicing the vertical tendons.

The concrete containment wall, dome, and basemat inner surfaces are lined with 6.0 mm (1/4 in.) carbon steel and stainless steel plates that are anchored to the concrete to provide the required pressure boundary leaktightness. The other items integrally welded to the liner that form part of the overall pressure boundary include but are not limited to the equipment hatch, two personnel airlocks, various piping and electrical penetrations, and miscellaneous supports that are embedded in the concrete shell, such as the polar crane brackets and the main steam; feedwater; and heating, ventilation, and air conditioning lines. The liner plate system is not designed nor considered as a structural member but rather serves as a leaktight membrane and provides an inside formwork for the cylindrical wall and dome during concrete placement.

The staff reviewed the description of the RCB to ensure that it contains sufficient information that defines the primary structural aspects and elements that are relied upon to perform the RCB's safety related functions. To assess the acceptability of the RCB description in the DCD Tier 2 document, the staff followed the guidelines in SRP 3.8.1 and Section C.I.3.8.1.1, "Description of the Containment," of RG 1.206.

DCD Tier 2 Section 3.8.1.1 contains information on the general arrangement and physical features of the prestressed concrete containment, including the penetrations and attachments structurally connected to the containment. The description contains information on the 6.0 mm (0.25 in.) thick carbon steel and stainless steel liners that are anchored to the concrete shell, dome, and basemat essentially to provide the required pressure boundary leaktight barrier in the containment. It also provides information about the prestressing system used in the containment, including descriptions of the steel prestressing tendons, such as location, type of tendons, spacing, use of vertical buttresses, and other information.

The staff compared the design of the RCB for the APR1400 to those for similar design centers and previously licensed plants that use prestressed concrete for the containment structure to identify new and unique features in the APR1400 design. The staff noticed that there are two notable differences between the RCB designs of the previous licensed plants and the APR1400. First, the thickness of the common concrete basemat under the APR1400 RCB and AB ranges from 3.05 m to ~~332.15~~ m (10 ft. to 33 ft.). This concrete basemat thickness is much greater than those used for the previously licensed plants, whose basemats are approximately 2.90 m (9 ft., 6 in.) thick on average. The use of a much thicker concrete basemat is not significant; it is related to the design of the RCB walls and dome, and also because the tendon gallery is located within the basemat, unlike other prestressed concrete containments where the tendon gallery is either not integrally connected or is not within the basemat region. The thicker concrete foundation slab does require some special construction techniques and measures, which are discussed in SER Section 3.8.5.

10.06 m

In RAI 200-8225, Question 03.08.02-01, the staff asked the applicant to clarify the statements made in DCD Tier 2, Sections 3.8.2 and 3.8.2.1.3.2, and elsewhere, as appropriate, to indicate that the portion of the penetration sleeves that are not backed by concrete are classified as ASME Class MC components and are covered in DCD Tier 2 Section 3.8.2. The staff also asked the applicant to provide a description and figure of the fuel transfer tube penetration assembly that is comparable to the information provided for the other penetrations, provide design and analysis procedures, and provide the structural acceptance criteria.

In its response dated December 31, 2015 (ADAMS Accession No. ML15365A551), the applicant stated that the portion of the concrete containment pressure boundary that is not backed by concrete, such as the equipment hatch, personnel airlocks, and Class MC penetration assemblies, including the fuel transfer tube penetration sleeve, are designed in accordance with ASME Code, Section III, Division I, Subsection NE. The applicant further stated that the equipment hatch, personnel airlocks, electrical penetrations, and fuel transfer tube penetrations are vendor designed components. The applicant included a COL 3.8(4), directing the COL applicant to provide a detailed analysis and design procedure for the fuel transfer tube penetration assembly. Additionally, the applicant described the fuel transfer tube sleeve and bellows in DCD Tier 2, Sections 3.8.2.4, "Design and Analysis Procedures," and 3.8.2.5, "Structural Acceptance Criteria," and included Figure 3.8-25, "Fuel Transfer Tube Sleeve and Bellows," which shows the conceptual design of the fuel transfer tube sleeve and bellows.

The staff's review of the applicant's detailed description of its design and analysis approach for the steel portions of the concrete containment that are not backed by concrete revealed that the applicant provided sufficient information that demonstrates that the primary structural integrity of these portions of the RCB are maintained and are capable of performing their intended safety functions. The staff considers the response to be acceptable because the applicant (1) indicated in applicable sections of DCD Tier 2 that the design of the various penetrations that are not backed by concrete are analyzed and designed in accordance with ASME Code, Section III, Division I, Subsection NE; (2) provided a markup of the DCD that includes additional information and a figure of the fuel transfer tube penetration; and (3) provided information demonstrating that the portion of the RCB not backed by concrete, meet the requirements in 10 CFR 50.55a; and the guidance in RG 1.206 and SRP Section 3.8.2.II.1. The staff confirmed that DCD Tier 2, Revision 1, dated March 10, 2017, was revised as committed in the response to RAI 200-8225, Question 03.08.02-01. Accordingly, the staff considers RAI 200-8225, Question ~~03.08.01-07~~, resolved.

3.8.2.4.2 *Applicable Codes, Standards, and Specifications*

In DCD Tier 2, Section 3.8.2.2, "Applicable Codes, Standards, and Specifications," and Table 3.8-1, "Codes, Standards, Specifications, and Regulations," the applicant presented the following industry codes, standards, and specifications that are applicable for the design, construction, materials, testing, and inservice inspections of the steel portion of the RCB pressure boundary not backed by concrete:

- ASME Code, Section III, Division 1, 2007 Edition through 2008 Addenda
- ASME Code, Section XI, Subsection IWE, 2007 Edition through 2008 Addenda

03.08.02-01

resolved pending incorporation of the DCD markup in the next revision of the DCD. This item is tracked as a **Confirmatory Item**.

In DCD Tier 2, Section 3.8.5.4.2, “Analysis of Settlement during Construction,” the applicant provided limited description as to how settlement is evaluated. In APR1400-ES-NR-14006-P, Revision 1, the applicant described the evaluation of the settlement of the NI basemat; however, DCD Tier 2, Section 3.8.5.4, “Design and Analysis Procedures,” did not reference the report. Furthermore, it was not clear to the staff how the criteria in SRP Section 3.8.5.II.4 E, J, and K, are implemented.

Therefore, the staff issued RAI 255-8285, Question 03.08.05-9, on October 19, 2015 (ADAMS Accession No. ML15293A569), requesting the applicant to describe the design and analysis procedures and to explain how the elements described in SRP Section 3.8.5.II.4 E, J, and K, are incorporated in the APR14000 design, and to include this information in DCD Section 3.8.5.

The applicant submitted the final response to RAI 255-8285, Question 03.08.05-9, on ~~January 1, 2016~~ (ADAMS Accession No. ML17009A400). Based on the review, the applicant’s response and the staff’s evaluation for each item of this RAI are given below.

1. Criteria related to SRP Section 3.8.5.II.4.E - evaluation of settlement: January 9, 2017

   The effects of (a) static and dynamic settlements, (b) short term and long term settlements, (c) of soil type on settlement, and (d) of foundation type and size on settlement are addressed under RAI 255-8285, Question 03.08.05-7, which is evaluated below in this SER. Therefore, item 1 under RAI 255-8285, Question 03.08.05-9, is resolved.

2. Criteria related to SRP Section 3.8.5.II.4.G - evaluation of stiff and soft spots:

   The applicant responded that the stiff and soft spots are not predictable before the site survey or site excavation for the specific site. The applicant further described that if stiff and soft spots were found during excavation, the COL applicant shall perform basemat analysis considering stiff and soft spots per item 2 of COL 3.8(12) within RAI 255-~~8283~~, Question 03.08.05-7. Therefore, item 2 under RAI 255-8285, Question 03.08.05-9, is resolved.

3. Criteria related to SRP Section 3.8.5.II.4.J - evaluation of settlement during construction: 8285

   The applicant responded that the evaluation of settlement during the construction sequence is described in RAI 255-~~8283~~, Question 03.08.05-7. The applicant also described that if the actual soil status and loss of cement from the mudmat were to be expected after the site survey or site excavation, loss of subgrade contact due to loss of cement from a mudmat is considered corresponding to the actual site status as specified in items 4 and 5 of COL 3.8(12) within RAI 255-~~8283~~, Question 03.08.05-7. Therefore, item 3 under RAI 255-8285, Question 03.08.05-9, is resolved.

4. Criteria related to SRP Section 3.8.5.II.4.K - stiffness modeling of soil material in seismic analysis:

analysis for NI common basemat and superstructures (AB, IS and RCB) with various soil profiles, and (2) identify the two types of settlement (Maximum Allowable Differential Settlement inside Building and Maximum Allowable Differential Settlement between Buildings) criteria tabulated in DCD Tier 2 Table 2.0-1, that the COL applicant shall satisfy. The staff finds the response acceptable because the applicant addressed the construction sequence analysis model and analysis throughout the life of the plant, and four types of settlement criteria in accordance with SRP Section 3.8.5.II.4.

3. The applicant also described the four types of settlement consisting of (1) the maximum vertical settlement, (2) tilt settlement, (3) differential settlement between adjacent structures, and (4) angular distortion, in DCD Tier 2 Section 3.8.5.4.2.2, "Various Settlements." The applicant furthermore tabulated and provided figures of the maximum settlements values under construction sequence and post-construction condition for soil profiles of S1 and S8. The staff finds the response acceptable because the applicant provided the description of the analyses performed for construction sequence and settlement, and described the four types of settlements in DCD Tier 2 Section 3.8.5.4.2.2, "Various Settlements."

4. The applicant tabulated the maximum vertical differential settlements for construction and post-construction for soil profiles of S1 and ~~S2~~ S8 for NI, EDG and DFOT buildings, which are presented in DCD Tier 2 Table 3.8-14. The applicant also provided markups for DCD Sections 3.8.5.8, 3.9A.1, and 3.9A.2, which provide the analysis approach for evaluating settlements and seismic anchor movements for SSCs spanning between structures. The staff finds the response acceptable because the applicant provided the maximum vertical differential settlement criteria for construction and post-construction for the NI, EDG and DFOT buildings in DCD Tier 2 Table 3.8-14, and provided the analysis approach for design of SSCs subjected to differential settlements and seismic anchor movements.

5. The applicant provided a new revised COL 3.8(19) [this COL item was originally identified as COL 3.8(12) in the response dated August 2, 2016 (ADAMS Accession No. ML16222A402)]. The revised COL item indicates: (1) The site–specific soil profiles shall be developed; (2) A list is provided identifying the potential differences between the site surveyed soil characteristics and the DCD; (3) The differential settlement of the basemat and soil bearing pressure shall be checked against the acceptance criteria in DCD Tier 2 Table 2.0-1; (4) The seismic Category I structures will be built in accordance with the construction sequence used in the site-specific construction sequence analysis (described in COL 3.8(18)); (5) If a site-specific evaluation is required, the COL applicant should perform a construction sequence analysis to ensure the acceptance criteria in DCD Tier 2 Table 2.0-1, is met; and (6) The effects of construction sequence shall be considered in the design of seismic Category I structures. The staff finds the response acceptable because the applicant provides all the necessary items to be considered for the COL applicant in order to meet the construction sequence and settlements that were used in the design of the plant described in the DCD. This approach is consistent with the criteria in SRP Section 3.8.5.II.K.i and 3.8.5.III.8.

Furthermore, in its response, the applicant provided markups to DCD Tier 1, Tier 2, Chapter 2.0, Section 3.8.5, and APR1400-E-S-NR14006-P/NP, Revision 3, to incorporate detailed

Therefore, the staff needed additional information in order to perform its safety review of the DCD application, and issued RAI 255-8285, Question 03.08.05-17, on October 19, 2015 (ADAMS Accession No. ML15293A569), requesting the applicant to describe in greater detail the approach used for differential displacement. The staff also requested the applicant to explain why the differential displacements were not considered for all time steps, which might lead to a higher differential displacement. Additionally, the staff noted that the applicant provided differential settlements between NI Basemat and TGB Basemat for the static loading case in Section 4.1.2. The staff noted that the differential settlement for S4 (moderate soil stiffness) is much larger than the differential settlements for S1 (soft soil) and S8 (stiff soil) properties. Therefore, the staff requested the applicant to address this inconsistency.

The applicant submitted the revised response to RAI 255-8285, Question 03.08.05-17, in a letter dated August 29, 2017 (ADAMS Accession No. ML17241A142). The response referred to RAI 255-8285, Question 03.08.05-7, for the detailed explanation and analysis of the effects from construction sequence on design and the various types of settlements during the construction sequence and post-construction phases of the NI. As a result, the markups for the DCD and APR1400-E-S-NR-14006-P, Revision 3, are provided in RAI 255-8285, Question 03.08.05-7. Therefore, the staff finds RAI 255-~~8295~~, Question 03.08.05-17, acceptable, pending incorporation of the DCD markup in the next revision of the DCD. This item is tracked as a **Confirmatory Item**.

8285

3.8.5.4.5 *Structural Acceptance Criteria*

The staff reviewed the structural acceptance criteria used for the foundations to ensure that they meet the applicable requirements in 10 CFR 50.55a; 10 CFR Part 50, Appendix B; and GDC 1, GDC 2, GDC 4, and GDC 5, and are in accordance with the guidance provided in SRP Section 3.8.5.II.5.

In DCD Tier 2, Section 3.8.5.5, “Structural Acceptance Criteria,” the applicant described the structural acceptance criteria for the RCB and other seismic Category I structures. The applicant referred to the structural acceptance criteria in Sections 3.8.1.5, “Structural Acceptance Criteria,” for the foundation of RCB and Section 3.8.4.5, “Structural Acceptance Criteria,” for the foundations of AB and EDG building. For the stability evaluation of overturning, sliding, and flotation, the applicant referred to the acceptance criteria presented in DCD Tier 2 Table 3.8-10. The applicant also provided APR1400-E-S-NR-14006-P, Revision 1, which describes the stability evaluation and the construction sequence analysis of the NI common basemat, EDGB basemat and DFOT basemat.

DCD Tier 2, Section 3.8.5.5, “Structural Acceptance Criteria,” also identified that the COL applicant is to provide reasonable assurance that the design criteria listed in Table 2.0-1, “Site Parameters,” are met or exceeded, as described in COL 3.8(6). These design criteria include parameters of maximum settlement, maximum soil angle of internal friction, and allowable soil bearing pressure. Even though, the applicant identified the maximum differential settlement of foundations, it is not clear to the staff whether the scope (types of settlements) and maximum values for settlement are appropriate as discussed in SER Section 3.8.5.4.4. The issues and staff evaluation related to the settlement criteria were captured in RAI 255-8285, Question 03.08.05-7. The staff determined that the maximum value for the soil angle of internal friction of 35 degrees is acceptable because that results in a coefficient of friction of 0.70 which integrity for normal, off-normal, and postulated loads/events in accordance with the acceptance criteria to meet the regulatory criteria described in Section 3.9.2.3 below. In accordance with the provision of RG 1.20, regulatory position C.1.4, the applicant classifies the APR1400 reactor internals as non-prototype Category I, with the Palo Verde Nuclear Generating Station (PVNGS) Unit 1, Westinghouse System 80 reactor vessel internals (RVI) as the valid prototype.

ITAAC: The ITAAC associated with DCD Tier 2 Section 3.9.2, are given in DCD Tier 1, Sections 2.4.1 and 2.14.

Topical Reports: There are no topical reports for this area of review.

Technical Reports: delete ical reports supporting t , Revision 0 resented in DCD Tier 2 Section 3.9.2, are as follows:

- ~~CVA for RVI~~ APR1400-Z-M-NR-14009-P, "Comprehensive Vibration Assessment Program for the Reactor Vessel Internals," November 2014 (Proprietary)

- APR1400-Z-M-NR-14010-P, Revision 0, "Structural Analysis of Fuel Assemblies for Seismic and Loss of Coolant Accident Loading," November 2014 (Proprietary)

- APR1400-E-S-NR-14004-P, Revision 0, "Evaluation of Effects of HRHF [Hard Rock High Frequency] Response Spectra on SSCs," November 2014 (Proprietary)

- APR1400-E-S-NR-14001-P, Revision 0, "Seismic Design Bases," November 2014 (Proprietary)

3.9.2.3 Regulatory Basis

The relevant requirements and the associated acceptance criteria are given in SRP 3.9.2, and are summarized below. Review interfaces with other SRP sections can be found in SRP 3.9.2.

- The requirements in 10 CFR 50.55a, as it relates to the design, fabrication, erection, and testing of SSCs in accordance with quality standards commensurate with the importance of the safety function to be performed.

- 10 CFR Part 50, Appendix A, GDC 1, as it relates to the design, fabrication, erection, and testing of SSCs in accordance with quality standards commensurate with the importance of the safety function to be performed.

- GDC 2, as it relates to the ability of SSCs, without loss of capability to perform their safety function, to withstand the effects of natural phenomena, such as earthquakes, tornadoes, floods.

- 10 CFR Part 50, Appendix S, Section IV(a)(ii), as it relates to certain SSCs that must be designed to remain functional for a SSE.

- GDC 4, as it relates to the protection of SSCs against dynamic effects, 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.

- GDC 14, as it relates to designing SSCs of the RCPB to have an extremely low probability of rapidly propagating failure and gross rupture.

- GDC 15, as it relates to designing the reactor coolant system (RCS) with sufficient margin to assure that the RCPB is not exceeded during normal operating conditions, including AOOs.

- 10 CFR Part 50, Appendix B, Section II Quality Control Program, as it relates to the quality assurance criteria for the dynamic testing and analysis of SSCs.

- 10 CFR 52.47(b)(1), which requires that a DC application include 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 DC is built and will operate in accordance with the DC, the provisions of the Atomic Energy Act of 1954 and the NRC's regulations.

, Revision 3

Acceptance criteria to meet the above requirements can be found in:

- RG 1.20, as it relates to the reactor internals vibration analysis and testing methodologies,

- RG 1.61, Revision 1, as it relates to the damping values used for dynamic analysis,

- RG 1.68, "Initial Test Programs for Water-Cooled Nuclear Power Plants," as it relates to the initial test programs for piping and reactor internals,

- RG 1.92, Revision 2, as it relates to response combination methods,

- Guidance for test specifications, as provided in ASME OM-S/G-1990, "Standards and Guides for Operation of Nuclear Power Plants," Part 3, "Requirements for Preoperational and Initial Start-Up Vibration Testing of Nuclear Power Plant Piping Systems," and Part 7, "Requirements for Thermal Expansion Testing of Nuclear Power Plant Piping Systems," and

- ASME Boiler and Pressure Vessel (BPV) Code (or, the Code), Section III, as incorporated by reference in 10 CFR 50.55a.

3.9.2.4 Technical Evaluation

There are six main areas of review in this section. Because of the distinctive character for each area of review, the technical evaluation provides additional details on the summary of the application and identifies the regulatory basis. The DCD Tier 1 information associated with reactor internals initial tests is found in DCD Tier 1 Section 2.4.1, which is evaluated in SER Section 14.2.

3.9.2.4.1 *Piping Vibration, Thermal Expansion, and Dynamic Effects Testing*

The specific areas of review for testing in the application include the systems that are monitored, test program details, acceptance criteria, and possible corrective actions when excessive vibration or indications of thermal motion restraint occur. SRP Section 3.9.2, states that piping vibration, safety relief valve vibration, thermal expansion, and dynamic effects testing for specific high- and moderate-energy piping and their supports and restraints should be conducted during startup functional testing to demonstrate that the systems meet the relevant requirements of GDC 1 that relates to the design, fabrication, erection, and testing of SSCs in accordance with quality standards commensurate with the importance of the safety function to be performed; GDC 14 that relates to designing SSCs of the RCPB to have an extremely low probability of rapidly propagating failure and of gross rupture; and GDC 15 that relates to designing the RCS with sufficient margin to assure that the RCPB is not exceeded during normal operating conditions, including AOOs. The systems to be monitored should include: (1) all ASME Class 1, 2, and 3 piping systems, (2) high-energy piping systems inside seismic Category I structures, (3) high-energy portions of systems whose failure could reduce the functioning of seismic Category I plant features to an unacceptable safety level, and (4) seismic Category I portions of moderate-energy piping systems located outside the containment. The purpose of these tests is to confirm that these piping systems, restraints, components, and supports have been adequately designed to withstand the dynamic loadings and operational transient conditions encountered during service as required by the Code, and to confirm that normal thermal motion is not restrained.

In DCD Tier 2 Subsection 3.9.2.1, the applicant states that the testing of piping vibration, thermal expansion, and dynamic effects are tested during the ITP as delineated in DCD Tier 2 Section 14.2. The ITP is implemented to demonstrate that these piping systems, restraints, components, and supports have been designed to withstand flow-induced dynamic loading under the steady-state and operational transient conditions anticipated during service, to confirm that proper allowance for thermal contraction and expansion is provided, and to demonstrate that piping vibrations are within the acceptable level such as those caused by an in-line component trip. The DCD further states that the supports and restraints necessary for operation during the life of the plant are considered to be parts of the piping system. Therefore, the staff requested the applicant in RAI 151-8078, Question 03.09.02-1, dated October 3, 2015 (ADAMS Accession No. ML15234A007), to justify the applicability of the stress limits in the referenced guidance of ASME OM-S/G during steady state vibration throughout the 40-year licensing period.

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In its response to RAI 151-8078, Question 03.09.02-1, dated December 1, 2015 (ADAMS Accession No. ML15335A026), the applicant stated that the APR1400 design used the criteria that the stress limit for steady-state vibration is the endurance limit of the piping material, consistent with ASME OM-S/G-1990, Part 3. The allowable endurance stress values for the plant life are the stress values of the ASME Code Section III, Division 1, Appendix I, design fatigue curve (S-N Curve) at ~~1011~~ stress cycles. The applicant also indicated that a detailed evaluation will be performed if the steady state vibration is over ~~1011~~ stress cycles. Because the stress limits for vibration follow the Code, the staff concludes that the applicant's evaluation using the endurance stress limits for steady state vibration is adequate and acceptable for the design life of the piping system. Therefore, the staff considers RAI 151-8078, Question 03.09.02-1, resolved and closed.

The staff reviewed DCD Tier 2, Sections 3.9.2 and 14.2.12.1, which state that the ITP of piping systems is applicable to the ASME BPV Code Section III, Class 1, 2, and 3 piping systems. The applicant did not, however, identify testing applicable to other piping systems not designed to for the APR1400 design throughout DCD Tier 2 (referenced as the 2007 Edition in some locations) and to justify any differences from the guidance in SRP 3.9.2. In addition, the reference to, “OM Part 7,” (as well as other similar references to other parts) should be clarified in the DCD to give the complete reference (e.g., OM-S/G-2007, Part 7).

In its response to RAI 151-8078, Question 03.09.02-16, dated December 1, 2015 (ADAMS Accession No. ML15335A025), the applicant stated that the DCD will be revised to reflect that the piping system tests will be performed in accordance with ASME OM-S/G-1990. The staff confirmed that DCD Revision 1, incorporated these changes; therefore, the staff considers RAI 151-8078, Question 03.09.02-16, resolved and closed.

The applicant’s vibration criteria are based on ASME OM S/G-2007, Part 3, paragraph 3.2.1.2. For austenitic stainless steels, the stress limits are obtained from Figures I-9.2.1 and I-9.2.2, of the Mandatory Appendix I to Section III of the ASME BPV Code. In addition, the DCD Tier 2, states that the allowable stress reduction factor provides reasonable assurance that the alternating stress S_{alt} is based on the during the design life. In RAI 151-8078, Question 03.09.02-5, the staff requested the applicant to provide a justification whether the fatigue strength at ~~106~~ 10^6 cycles with the reduction factor would be conservative.

In its response to RAI 151-8078, Question 03.09.02-5, dated December 1, 2015 (ADAMS Accession No. ML15335A026), the applicant stated that for APR1400 design, the allowable stress limits are obtained at ~~1011~~ 10^{11} cycles in accordance with ASME Section III, Mandatory Appendix I, design fatigue curve. The staff considers the APR1400 design to be adequate and consistent with ASME OM-S/G-1990, Part 3, consistent with SRP 3.9.2, acceptance criterion 7. Therefore, the staff considers RAI 151-8078, Question 03.09.02-5, resolved and closed.

In DCD Tier 2 Section 3.9.2, the applicant states that the dynamic transient vibrations are usually induced by rapid start or trip of a pump or turbine, or the quick closing or opening of valves such as turbine-stop valves and various types of control valves. The dynamic transients also occur as a result of rapid actuation of safety/relief valve (SRV) opening or as a result of unexpected events. The staff reviewed DCD Tier 2 Section 14.2, and did not find any ITP element that tested the dynamic transient conditions stated above. Therefore, in RAI 151-8078, Question 03.09.02-6 (ADAMS Accession No. ML153234A007), the staff asked the applicant to provide appropriate ITP test programs for each of the transient vibration conditions in accordance with the guidance of RG 1.68, and ASME OM-S/G-2007, Part 3, such that APR1400 would meet GDC 14 and GDC 15.

In its response dated March 24, 2016 (ADAMS Accession No. ML16084A991) to RAI 151-8078, Question 03.09.02-6, the applicant stated that each piping transient test will be performed in connection with the system test during the Power Ascension Test. ITP 14.2.12.1.118, "Balance-of-Plant Piping Vibration Measurement Test,” includes testing of the systems to withstand flow induced dynamic loadings under the steady state and operational transient conditions and references DCD Tier 2 Section 3.9. The associated test procedures will include the detailed test specifications in accordance with the general requirements of RG 1.68, and the specific vibration testing requirements of ASME OM Part 3. To ensure that the requirements of RG 1.68, and ASME OM are included, DCD Tier 2 Subsection 3.9.2.1, will be updated to specify that these specific provisions are addressed as part of the test program. Because the transient

In DCD Tier 2 Section 3.9.2.3.1.1, the applicant states that the random hydraulic forcing function is developed by experimental methods and the forcing function is modified to reflect the flow rate and density differences based on an analytical expression found in the Penzes paper. However, the staff did not find an expression that is physically suitable to modify the random turbulent flow loadings represented by power spectrum density. In RAI 151-8078, Question 03.09.02-10, the staff requested that the applicant provide a description of the experimental methods and the analytical expression that modified the random forcing functions.

In a response dated October 23, 2015 (ADAMS Accession No. ML15296A568), the applicant stated that the wording used in the DCD Tier 2 Section 3.9.2.3.1.2, was intended to indicate that the random hydraulic forcing function is developed based on the System ~~80+~~ 80 CVAP preoperational testing data and proposed an associated DCD revision. In the response, the applicant also provided the expressions used to modify the forcing function when necessary to reflect the flow rate (velocity) or density differences between the testing data and the design.

In its revised response dated September 30, 2016 (ADAMS Accession No. ML116274A418), the applicant indicated that equations the Penzes paper were used to develop the power spectrum curve based on the measured data in the corresponding frequency domain. The staff evaluated the information provided by the applicant and finds that the power spectrum curves obtained for APR1400 are acceptable considering the conservatism of the resulting power spectrum curves which envelop the measured spectrum data. Therefore, the staff considers RAI 151-8078, Question 03.09.02-10, resolved and closed.

The applicant performed finite element analyses for each of the reactor internals components using mathematical models. The core support barrel (CSB) assembly is modeled with axisymmetric shell element using the ASHSD computer code. The ANSYS library elements are used for other CSB assembly components such as the lower support structure (LSS), in-core instrument (ICI) support system, core shroud, and the upper guide structure (UGS) support barrel assembly, which consists of the UGS support barrel, fuel alignment plate, UGS support plate, and control element assembly (CEA) guide tubes. The mathematical model is used to determine the static and dynamic characteristics as well as periodic and random response analyses using ANSYS computer code. The applicant stated that the ANSYS code computes the root mean square (RMS) displacements, loads, and stresses in a multi-degree-of-freedom linear-elastic structural model subjected to stationary random dynamic loadings. The DCD also states that a value of 3 times the RMS is used for considering peak responses to random loading. Considering that the use of the value 3 times the RMS is common design practice in the industry and that APR1400 used an absolute sum for the combination of pump pulsation, vortex shedding and turbulent loads in calculating stresses and fatigue usage factors of ASME BPV Code Section III components and reactor internals, the staff concludes that the methodologies in calculating the random responses are acceptable.

3.9.2.4.4 *Preoperational Flow-Induced Vibration Testing of Reactor Internals*

In DCD Tier 2 Section 3.9.2.4, the applicant states that the APR1400 is classified as a non-prototype Category I design, consistent with RG 1.20, and that the PVNGS Unit 1, System ~~80+~~ 80 reactor is the valid prototype. The applicant also stated that its evaluation of the PVNGS CVAP report, “A Comprehensive Vibration Assessment Program for PVNGS Unit 1 (System 80 Prototype),” ~~CEN-263, Revision 1,~~ CEN-263(V)-P, Revsion 1-P dated January 1985, for analytical predictions, test measurements, and visual inspection results leads to the conclusion that the System ~~80+~~ 80 prototype reactor internals are structurally adequate and acceptable for long-term operation. The staff reviewed the data comparison provided in DCD Tier 2, Tables 3.9-15, 3.9-16, and 3.9-17, and found that the PVNGS Unit 1, design and the APR1400 design are substantially the same with regard to arrangement, design, size, and operating conditions. Consistent with the guidance in RG 1.20, the applicant provided a CVAP report (APR1400-Z-M-NR-14009-P) for the APR1400 reactor internals, as well as steam generator internals and the RCS piping and piping attached to the RCS, to support the designation of PVNGS Unit 1, as the prototype for APR1400. In addition, the APR1400 CVAP discussed in detail the slight differences of the designs and the RVI parameters and concluded that the design differences will not substantially alter the behavior of the flow transients, and the response of the reactor internals. Therefore, based on a review of the above-referenced information, the staff concludes that the applicant provided adequate demonstration for APR1400 to be classified as non-prototype seismic Category I reactor internals, with the PVNGS Unit 1, System ~~80+~~ 80 reactor being the designated prototype reactor.

In DCD Tier 2 Section 3.9.2.4, the applicant states that evaluation of steam generator internals is included in Appendix A of the CVAP report, APR1400-Z-M-14009-P, Revision 0. The staff reviewed Appendix A of this technical report and found that it presents an analysis based on the turbulent loading that concludes the stresses in the critical locations are small and acceptable. The analysis, however, does not address the fluid-structural interaction or flow-induced vibration due to cross flow conditions. In light of the recent operating experience with steam generator tube degradation at San Onofre Nuclear Generating Station, the staff requested in RAI 151-8078, Question 03.09.02-11, that the applicant demonstrate that the APR1400 steam generator tube bundle design will prevent such degradation by: (1) discussing the dynamic characteristics of the U-bend assembly including frequencies and mode shapes and describing the U-bend support configuration, or (2) providing the comparison between the APR1400 steam generators and similar steam generators (such as PVNGS Unit 1 replacement steam generators) that have operated without such adverse flow effects.

In its response dated October 23, 2015 (ADAMS Accession No. ML15296A568), the applicant provided the fluid induced vibration (FIV) assessment of the APR1400 steam generator tube bundle including the modal analysis results, as well as a comparison of the APR1400 steam generator to similar operating nuclear plant steam generator tube bundle designs. The staff reviewed the applicant’s presentation of the ANSYS finite element model for the tube modal analysis, which includes straight and U-bend tubes supported by various features. The applicant evaluated both fluid elastic instability and random turbulence excitation for the tubes. For fluid elastic instability, the stability ratio is determined by dividing the effective velocity by the critical velocity. The staff considered the applicant’s calculation results to demonstrate conservative stability ratios with sufficient safety margin. For random turbulence excitation, the applicant’s calculations showed that the maximum root-mean-square displacements are within the allowable limits such that the stress is less than the allowable limits. Based on the evaluation of the applicant’s response, the staff concludes that the applicant provided adequate analytical information to demonstrate the APR1400 design will operate below the critical flow limit with sufficient margin for FIV effects on the steam generator tubes. Therefore, the staff considers RAI 151-8078, Question 03.09.02-11, resolved and closed.

In its response to RAI 92-8068, Question 03.09.05-17, dated October 16, 2015 (ADAMS Accession No. ML15289A615), the applicant stated that the reactor internals are designed to have no interference between reactor internals and the reactor vessel. A table of the minimum and maximum cold and hot gaps between the core support barrel outlet nozzle and the reactor vessel outlet nozzle was also provided. The applicant further stated that the cold gap between the core support barrel outlet nozzle and the reactor vessel outlet nozzle is calculated considering dimension and positional tolerances according to the requirements for alignment. The hot gap between the core support barrel outlet nozzle and the reactor vessel outlet nozzle is calculated considering the radial growth and contraction of the reactor vessel and the reactor internals. The applicant also provided equations used to calculate: (1) the radial growth of the reactor vessel due to pressure; (2) the radial growth of the reactor vessel due to temperature; (3) the radial contraction of the core support barrel due to pressure; and (4) the radial growth of the core support barrel due to temperature.

In a supplemental response to RAI 92-8068, Question 03.09.05-17, dated February 19, 2016 (ADAMS Accession No. ML16050A245), the applicant stated that the radial contraction of the core support barrel is induced by the different flow velocities between the core support barrel inside wall and outside wall.

The staff evaluated the information provided by the licensee and found that there is no interference between reactor internals and the reactor vessel under both cold and hot conditions. Therefore, the staff considers RAI 92-8068, Question ~~03.09.05-174~~, resolved and closed.

03.09.05-17

Design Bases for Reactor Internals – Classification

In DCD Tier 2 Table 3.9-12, the applicant states that the reactor internals are designed to meet the design limits defined in ASME BPV Code, Section III, Subsection NG-3221, for design loadings. The reactor internals are classified as safety Class 3 and seismic Category I. DCD Tier 2 Table 3.2-1, lists the core support structures as safety Class 3, Quality Group C, seismic Category I, in full compliance with the 10 CFR Part 50, Appendix B, quality assurance requirement. Note N-2 states that only those core support structures necessary to support and restrain the core and to maintain safe shutdown capability are classified as seismic Category I.

GDC 1, and 10 CFR 50.55a, require that SSCs important to safety be designed to quality standards commensurate with the importance of the safety functions performed. However, it was initially unclear to the staff whether note N-2 from DCD Tier 2, Table 3.2-1 encompasses all core support structures, and if there are any core support structures that are not within the scope of note N-2, and therefore not classified as seismic Category I. In addition, in DCD Tier 2, Table 3.9-12 and Table 3.2.1, the applicant does not provide any safety class, quality group, seismic category classification, or quality assurance requirement for reactor internal structures other than core support structures. Therefore, in RAI 92-8068, Question 03.09.05-18, the staff requested the applicant to provide information for the issues identified above. The staff evaluated portion of DCD Tier 2 Table 3.2-1, and component classification in SER Sections 3.2.1 and 3.2.2.

In its response to RAI 92-8068, Question 03.09.05-18, dated October 16, 2015 (ADAMS Accession No. ML15289A615), the applicant stated that all of the core support structures within assumptions made in determining the dose contributions from these components. Finally, it was unclear if the same source terms were used to determine post-accident TID values for EQ as were used to determine post-accident radiation zoning in DCD Tier 2, Figures 12.3-30 through 12.3-51. Therefore, the staff requested that the applicant clarify the methodology that was used in calculating accident source terms for the purposes of EQ and post-accident zoning and access to vital areas. The staff issued RAI 8089, Question 03.11-11, requesting the applicant to provide this information.

In the responses to Question 03.11-9 (ADAMS Accession No. ML16215A124), and Question 03.11-11 (ADAMS Accession Nos. ML16103A492 and ML16217A383), for Revision 1 of the response, the applicant made significant changes to the information in the DCD and APR1400-E-X-NR-14001-P, and provided new information describing how the normal and accident TID values were calculated. The response to Question 03.11-11, provided the methodology used for calculating the accident TIDs, while the response to Question 03.11-9, provided the methodology used for calculating the normal operation TIDs, the final calculated TID values, environmental classifications of equipment, and other information. The modifications and additions to the methodology for calculating EQ dose were so substantive that the general radiological EQ approach is summarized and reviewed below in its entirety, instead of evaluating the individual specific changes made in the response to each question.

delete A Determining

In the response to Questions 03.11-9, and 03-11-11, the applicant proposed updating APR1400- E-X-NR-14001-P, to provide the methodology used in calculating the maximum normal operation EQ dose calculations (Appendix ~~3A~~, “Calculation Method for ~~Determination of~~ Normal Condition TIDs for ~~Component~~ Environmental Qualification,” of APR1400-E-X-NR-14001-P), and accident EQ dose calculations (Appendix ~~3B~~, “Calculation Method ~~of Post-Accident TIDs for System Inside and Outside Containment~~,” of APR1400-E-X-NR-14001-P), for each room in the plant, which were then added together to give the maximum TID value for each room or plant area identified in Table 3 of APR1400-E-X-NR-14001-P (including areas inside the biological shield wall which were not identified previously). The TID dose calculations consider gamma, neutron, and beta radiation, as applicable. DCD Tier 2 Section 3.11.2.3, specifies that when actual qualification testing is performed that, instead of using a neutron source for neutron radiation, an equivalent gamma radiation dose may be used. As specified in the DCD, the gamma source must provide an equivalent simulation of the neutron exposure.

B

for Determining Post-accident Condition TIDs for Environmental Qualification

The locations of the significant equipment included in the EQ program, as well as their environmental and radiological classification (mild or harsh), and required operational time, are identified in Table 2, “Equipment Qualification Equipment List” of APR1400-E-X-NR-14001-P and Table 3.11-2, “Equipment Qualification Equipment List” of the DCD. However, for some equipment, the exact room in which the equipment is located is not identified in the DCD, and the COL applicant will determine where that equipment is located (this equipment is given the designation COL (7), instead of a room number).

Table 2 of APR1400-E-X-NR-14001-P, and DCD Tier 2 Table 3.11-2, also specifies the timeframe that the equipment is required to be operable following the onset of a design basis accident. Equipment is given the timeframe of either continuous, short-term, intermittent, or varies, depending on the specific operability requirements for the individual piece of equipment. For some of the equipment with a “short-term” timeframe, the specific timeframe the equipment

B

As described in Appendix ~~3B~~ of APR1400-E-X-NR-14001-P, the accident TID values were calculated based on the most limiting design basis accident, which in most cases, is the LOCA. The LOCA source terms are based on the core inventory release fractions for each radionuclide group at the gap release and early in-vessel release phases, listed in DCD Tier 2 Table 15A-2, "Fraction of Fission Product Inventory in Gap." The staff notes that these release fractions are also consistent with RG 1.183, and are therefore acceptable. Iodines in containment are assumed to be 4.85 percent elemental, 95 percent particulate, and 0.15 percent organic, which is also consistent with RG 1.183. Accident doses were calculated for a period of one year following the onset of an accident.

The applicant stated that different methodologies are used to calculate the accident TID values depending on the location within the plant.

Inside containment, the applicant noted that the TID values are calculated based on: (1) airborne fission products in the containment atmosphere; (2) fission products which plate-out on the containment walls; and (3) fission products in the IRWST sump water. Radioactive decay and subsequent daughter product buildup was considered. In addition, removal by the containment spray system is considered. The staff evaluated this approach and found it to be consistent with the methodology described in RG 1.89, and RG 1.183. Therefore, the staff finds this explanation to be acceptable.

During a LOCA, the accident doses will increase significantly in areas near the safety injection, shutdown cooling, and containment spray systems, in the auxiliary building, since these systems will be used to recirculate IRWST sump fluid. The direct dose contribution from components in these systems is considered in the EQ dose calculations. The source term for the recirculating IRWST fluid is provided in the response to RAI 8247, Question 12.02-16 (ADAMS Accession No. ML15343A410).

The source terms in the EQ analysis for components are generally modeled based on the source component dimensions, as was done in the Chapter 12, shielding and zoning analysis (as was discussed above). However, the applicant modeled pumps based on the diameter of the piping connected to the pump. This is conservative because it doesn't account for the extra shielding, beyond that of the piping, which would be expected to be provided by the pump housing. For heat exchangers, the applicant modeled the heat exchangers as a pipe with a diameter of the square root of the number of tubes that pass through the heat exchanger (counted twice for a U-tube heat exchanger) times the diameter of the tubes. The applicant indicates that this is an acceptable assumption because for the tube region, the shielding effects of the cooling water in the shell side and internal steel is not considered and for the plenum region of the heat exchanger, the same wall thickness and diameter as the tube region are applied, when in reality the wall thickness in the plenum region would be thicker than the tube region. The staff agrees that the applicant's assumed source term dimensions for the tube region are acceptable because it considers the entire volume of the recirculating fluid in the tubes, without considering the shielding effect that would be present from CCW fluid and internal shielding. Since the steel shell of the plenum region will be thicker than what is modeled in the source term calculations, the staff also agrees that the applicant's methodology is acceptable for the plenum region.

appears to indicate that two 60 inch diameter containment penetrations pass from containment into this room. During a LOCA, streaming of the radioactivity in the containment atmosphere, through penetrations, could constitute a significant radiation dose contribution to areas outside containment. The staff requested that the applicant consider radiation streaming through containment penetrations in this area and other areas where significant containment penetrations exist.

- The SFP Cooling HX rooms (100-A24A and 100-A32B) are listed as having a TID of 1,100 Gray (harsh radiation environment) in Table 3 of APR1400-E-X-NR-14001-P, however, the SFP HX Room Cubicle Cooler (VF-HV02B), which is located in that room is listed as being in a mild radiation environment in Table 2 of APR1400-E-X-NR-14001-P, and DCD Tier 2 Table 3.11-2. The applicant was asked to correct this discrepancy.

- As discussed above, for components labeled short-term in DCD Tier 2 Section 3.11.1.3, without a specific timeframe labeled in Table 2 of APR1400-E-X-NR-14001-P and DCD Tier 2 Table 3.11-2, it is unclear how long it is required to operate. In addition, the post-accident TID values are calculated for one year following the onset of a design basis accident. Therefore, it is unclear why DCD Tier 2 Section 3.11.1.3, specifies that most of the equipment is required to operate at least 6 months following the onset of a design basis accident.

- As discussed earlier, the applicant indicated that while Chapter 12, radiation zoning is based on the minimum wall and floor thicknesses provided in DCD Tier 2 Table 12.3-4, the response indicates that the EQ analysis is based on the actual structural wall and floor thicknesses. However, while the DCD provides structural thicknesses for many of the walls in the plant, not all of the actual structural wall and floor thicknesses are provided in the DCD. These structural thicknesses are needed in the DCD to ensure that the design is provided with the shielding assumed in the EQ analysis. The staff requested that the applicant provide this information in the DCD.

- The proposed Table 3 of APR1400-E-X-NR-14001-P, did not provide any TID information for the fuel handling area in the auxiliary building. The staff requested that the applicant include this information.

In Revision 1 of the response to Question 03.11-9 (ML17102A408), the applicant made several changes, including the following changes to resolve the above issues.

In Revision 1, the applicant revised the normal operation TID values for the operating area, specifying the normal operation gamma and neutron TID values. These values were consistent with the dose rate information provided in Calculation Package 1-310-N-376-002 (which was provided to staff as part of the radiation protection shielding audit), considering the extra 20 percent margin added for consideration of dose from other nearby areas and the extra 10 percent added for uncertainty. The calculation accounts for radiation streaming through the reactor vessel and up through the gap between the vessel and the ~~vessel~~ wall, to the operating floor (accounting for radiation streaming past and through the shield blocks). In Revision 3 of the response (ADAMS Accession No. ML17331A315), the applicant also provided actual dose rate information on the operating floor for the operating APR1400 unit in Korea (Shin Kori

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