9.0 AUXILIARY SYSTEMS

This chapter describes the U.S. Nuclear Regulatory Commission (NRC or Commission) staff's (hereinafter referred to as the staff) review of the United States - Advanced Pressurized Water Reactor (US-APWR) auxiliary systems. Auxiliary systems include: fuel storage and handling systems; water systems; process auxiliaries; air conditioning, heating, cooling and ventilation systems; and miscellaneous other auxiliary systems (e.g., fire protection, communication, lighting, and diesel generator systems).

9.1 Fuel Storage

9.1.1 Criticality Safety of New and Spent Fuel Storage

9.1.1.1 Introduction

The US-APWR includes facilities for the onsite storage of new fuel and irradiated spent fuel. Both the new fuel and spent fuel storage facilities are located within the US-APWR Fuel Building. The facilities are located in a reinforced concrete Seismic Category I structure.

New fuel is stored dry in a concrete vault in three racks each capable of holding a total of 180 fresh fuel assemblies. The new fuel racks (NFR) consist of two modules with 63 cells, and one module with 54 cells. The new fuel racks contain no neutron absorbing material, but have spatial flux traps between storage locations for reactivity control. The rack is fabricated using stainless steel type 304 plate. Under normal operating conditions the storage of fresh fuel is in dry conditions.

Spent fuel is stored in a stainless steel-lined concrete spent fuel pool (SFP) containing racks capable of holding a total of 900 fuel assemblies. The spent fuel racks (SFR) are divided into six modules within the common pool. Three modules have space for 144 cells, and the remaining three modules have space for 156 cells. The racks contain neutron absorbing material with spatial flux traps between storage locations for reactivity control. The racks are fabricated using stainless steel type 304 plate. Under normal operating conditions the storage of spent fuel is under borated water. Mitsubishi Heavy Industries, Ltd. (MHI), hereinafter referred to as the applicant, has selected Metamic^{TM} as the neutron absorber material, which has been developed by HOLTEC. The Revision 1 version of the submittal, being reviewed here, is given in Reference 1 [MUAP-07032-P, "Criticality Analysis for US-APWR New and Spent Fuel Racks," (Reference 1)] is based on HOLTEC analysis which included Metamic^{TM} as the neutron absorber material.

Damaged fuel is stored in special racks that can contain a total of 12 fuel assemblies in the vicinity of the spent fuel racks. The damaged fuel racks (DFR) are fabricated using stainless steel type 304 plate, and located apart from the SFR. Under normal operating conditions the storage of damaged fuel is under borated water.

Section 9.1.1 of the Design Control Document (DCD) provides the criticality evaluation of the fuel storage and handling systems.

9.1.1.2 Summary of Application

DCD Tier 1: DCD Tier 1, Section 2.7.6.1 and Section 2.7.6.2 of the US-APWR DCD, Revision 2, include a requirement that the fuel handling and storage systems maintain fuel in a subcritical array.

DCD Tier 2: The applicant has provided a Tier 2 description of the provisions for criticality safety in Section 9.1.1 of the US-APWR DCD, Revision 2, which also discusses fixed neutron absorber materials. Water chemistry and components are described in DCD 9.1.3.1 and 9.1.3.2, with a summary of components in Table 9.1.3-1, entitled "Recommended Spent Fuel Pit Water Chemistry Speciation". Descriptions are summarized here in part, as follows:

> Criticality analyses are performed for the US-APWR NFR and SFR to demonstrate $K_{eff} \leq 0.95$ during normal and credible abnormal conditions, assuming a maximum initial enrichment of 5.0 weight percent U^{235} and taking into consideration, any uncertainties due to fuel and rack manufacturing tolerances. In addition, the NFR will remain subcritical with $K_{eff} \leq 0.98$ under optimum moderation conditions (e.g.: a foam fire extinguishing agent). The criticality analyses assume that in some cases natural boron is dissolved in the water. In addition, in no case is a fuel depletion credit taken in estimating the material compositions of spent fuel and no credit is taken for the possibility of using burnable poison in selected fuel assemblies. Thus, in all the analyses presented fresh fully enriched (5 percent) fuel is assumed.

Technical Reports:

- MUAP-07032-P, "Criticality Analysis for US-APWR New and Spent Fuel Racks" (Reference 1), provides the criticality analyses, including description of analytical methods used in the criticality analyses.
- MUAP-07020, "Validation of the MHI Criticality Safety Methodology" (Reference 2), provides the criticality safety methodology.

Inspections, Tests, Analysis, and Acceptance Criteria (ITAAC): There are no ITAAC for this area of review.

Technical Specifications (TS): The TS associated with Tier 2, Section 9.1.1 are given in the Tier 2, Chapter 16, Section 3.7.12, Section 3.7.13, and Section 4.3.

US-APWR Interfaces: There are no plant interfaces for this area of review.

9.1.1.3 Regulatory Basis

The relevant requirements of the Commission's regulations for this area of review, and the associated acceptance criteria, are given in Section 9.1.1 of NUREG-0800, "Standard Review Plan [SRP] for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," New Fuel Storage - 50.68, hereinafter referred to as SRP 9.1.1, and are summarized below. Review interfaces with other SRP sections can be found in SRP 9.1.1.

1. General Design Criterion (GDC) 62, "Prevention of Criticality in Fuel Storage and Handling," as it relates to the prevention of criticality by physical systems or processes using geometrically safe configurations.

2. 10 CFR 50.68, “Criticality Accident Requirements,” as it relates to preventing a criticality accident and to mitigating the radiological consequences of a criticality accident.

3. 10 CFR 52.47(b)(1), “Contents of Applications,” as it relates to proposed ITAAC for the new and spent fuel storage facilities.

Acceptance criteria adequate to meet the above requirements are:

1. The criteria for GDC 62 are specified in American National Standards Institute (ANSI)/American Nuclear Society (ANS) 57.1, ANSI/ANS 57.2, and ANSI/ANS 57.3, as they relate to the prevention of criticality accidents in fuel storage and handling.

2. Compliance with 10 CFR 50.68 requires that the licensee either maintain monitoring systems capable of detecting a criticality accident as described in 10 CFR 70.24, “Criticality Accident Requirements,” thereby reducing the consequences of a criticality accident, or comply with the requirements specified in 10 CFR 50.68(b), thereby reducing the likelihood that a criticality accident will occur.

3. 10 CFR 52.47(b)(1), which requires that a Design Certification (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, the facility has been constructed and will operate in conformity with the Combined License (COL), the provisions of the Atomic Energy Act of 1954, and the NRC’s regulations.

The general acceptance criterion for compatibility and chemical stability of fixed neutron absorber materials with water in the fuel storage areas is based on:

1. GDC 14, “Reactor Coolant Pressure Boundary,” as it relates to assuring fuel pool material integrity, and

2. GDC 62, “Prevention of Criticality in Fuel Storage and Handling,” as it relates to preventing criticality accidents in the fuel pools.

The SRP acceptance criteria for compatibility of neutron-absorbing materials with fuel pool water are the relevant sections of ANSI/ANS-57.2 (Reference 5). The Electric Power Research Institute (EPRI) publication, “Pressurized Water Reactor Primary Water Chemistry Guidelines,” (Reference 6), represents the principal authority regarding Pressurized Water Reactor (PWR) water chemistry, and includes important information on fuel pool water. The EPRI Guidelines are considered an acceptable means of meeting regulatory criteria related to water chemistry.

9.1.1.4 Technical Evaluation

The staff’s review of DCD, Section 9.1.1 and supporting documentation, including MUAP-07032-P entitled “Criticality Analysis for US-APWR New and Spent Fuel Racks,” issued December 2009, and MUAP-07020-P, entitled “Validation of the MHI Criticality Safety Methodology,” issued December 2007, follows the procedures outlined in SRP 9.1.1, “Criticality

Safety of Fresh and Spent Fuel Storage and Handling," Revision 3. Compliance with regulatory requirements was verified based on the criteria delineated in Section 9.1.1.3 of this safety evaluation (SE). The TS identified in Section 9.1.1.2 above are reviewed in the applicable sections of this SE.

Design Bases

DCD, Tier 1, provides design requirements applicable to the criticality safety of the US-APWR fuel storage systems. In Section 2.7.6, the safety-related functions of the fuel handling system includes maintaining the fuel assemblies in a subcritical array. Tier 1, Section 2.7.6 specifies that fuel storage rack materials shall satisfy its intended safety purpose with regards to maintaining the fuel in a subcritical array. The DCD, Tier 1 design requirements are consistent with SRP 9.1.1 and are therefore found to be acceptable.

DCD, Tier 2, Section 9.1.1, states that the K_{eff} of fully loaded new fuel and spent fuel storage racks will not exceed 0.95, assuming that the racks are flooded with the potential moderator. In addition, the K_{eff} of the fully loaded NFR will not exceed 0.98 assuming optimum moderator conditions. A maximum new fuel enrichment level of five weight percent U^{235} is also specified in the application. These design stipulations are consistent with the guidelines contained in SRP 9.1.1, Subsection III and the requirements of 10 CFR 50.68.

While the applicant relies on soluble boron in the SFP to prevent criticality during a credible abnormal condition, the staff finds that the guidelines of SRP 9.1.1, Subsection III pertaining to partial credit for soluble boron are not applicable because the boron is not relied upon for normal conditions. TS 3.7.13 for minimum soluble boron concentration is intended to cover the possibility of a SFP loading or mislocation error.

The DCD states that criticality analyses demonstrated that the fuel storage rack geometry in combination with the integral neutron absorber material is sufficient to maintain the fuel in a subcritical condition as given above. Compliance with the guidance provided in ANSI/ANS-57.1, ANSI/ANS-57.2, and ANSI/ANS-57.3 with regard to criticality prevention is also stated in the Final Safety Analysis Report (FSAR).

The staff finds that the design bases described above for the fuel storage and handling systems meet the requirements of GDC 62 and 10 CFR 50.68(b).

Criticality Analysis Methodology

The criticality analysis of the US-APWR NFR, SFR was performed by Holtec International, which is also the designer and supplier of the storage racks.

The criticality analyses utilized the Monte Carlo Neutral Particle (MCNP)-5.1.40 computer code (Reference 4) which was developed at Los Alamos National Laboratory. MCNP-5.1.40 employs a Monte Carlo numerical methodology to perform neutron transport calculations. Cross section data are supplied by the (ENDF/B-V) library.

The MCNP code is a widely accepted methodology that has been previously utilized for licensing applications, including fuel storage criticality analyses. This code and cross section combination has been validated by the licensee, the validation is published in the Technical Report MUAP-07020, entitled "Validation of the MHI Criticality Safety Methodology, MUAP-

07020," issued December 2007 (Reference 2). The staff has reviewed this document and found the code and cross section validation acceptable.

Criticality Analysis Model Inputs and Assumptions

The criticality analyses performed by the licensee explicitly model the US-APWR fuel assembly. The staff has verified the key fuel assembly design parameters to assure consistency.

Criticality analyses are performed for the US-APWR NFR and SFP to demonstrate $K_{eff} \leq 0.95$ during normal and credible abnormal conditions, assuming a maximum initial enrichment of 5.0 weight percent U^{235} and taking into consideration uncertainties due to fuel and rack manufacturing tolerances. In addition, the new fuel storage racks will remain sub-critical with $K_{eff} \leq 0.98$ under optimum moderation conditions (e.g., a foam fire extinguishing agent). In the case of a mislocated fuel assembly in the SFP 800 Parts Per Million (ppm) of soluble boron is assumed to demonstrate $K_{eff} \leq 0.95$. In addition, in no case is a fuel depletion credit taken in estimating the material compositions of spent fuel. In all the analyses presented fresh fully enriched (five percent) fuel is assumed, with no credit taken for depletion due to burnup. Finally, the analysis assumptions includes: use of an infinite array model, no credit for neutron absorption in minor structural members, no credit for burnable absorber material, and evaluation at the moderator temperature of highest reactivity. All these assumptions were found to be conservative and are therefore found to be acceptable by the staff.

The fuel storage rack design inputs used in the criticality analyses are summarized by the licensee's Technical Report MUAP-07032-P, "Criticality Analysis for US-APWR New and Spent Fuel Storage Racks, MUAP-07032-P," issued December 2009 (Reference 1).

Criticality Analysis Results

As stated in NUREG-0800 SRP Section 9.1.1 and in accordance with GDC 62 and 10 CFR 50.68, new and spent fuel must be verified to remain subcritical during all credible storage and handling conditions. Descriptions of the US-APWR fuel storage facilities are provided in the licensee's submittal (Reference 1).

<u>New Fuel Storage</u>

The new fuel storage racks are enclosed in a concrete reinforced structure. The racks are designed to meet Seismic Category I requirements and therefore remain functional (i.e., maintain fuel in a safe and subcritical array) during a safe shutdown earthquake (SSE).

The NFR has the capacity to store 180 fresh fuel assemblies, each consisting of a 17x17 bundle including fuel pins, and control and instrumentation guide tubes. The nominal rack pitch is 43 cm (16.9 in), and the cell structural material of construction is type-304 stainless steel plate. Normally, fresh fuel is stored in a dry condition. A drain system assures that the NFR does not flood under normal conditions. In addition, the rack design precludes any deformation once it is loaded to capacity, and the double contingency principle precludes consideration of any dropped fuel assembly once flooding is assumed [Reference 1].

The acceptance criteria for meeting the regulatory requirements for verification of subcriticality in the new fuel storage facility are:

- $K_{eff} \leq 0.95$ under fully loaded, dry and flooded conditions, and
- $K_{eff} \leq 0.98$ under fully loaded, optimum moderation conditions.

The fuel assembly assumed in the criticality analysis shall be the highest reactivity fuel (five weight percentU^{235}) that will be stored in the new fuel storage racks. These criteria are specified in TS 4.3.

SRP 9.1.1 states that the applicant should consider the effects of a fuel assembly mislocation in the criticality NFRs. The applicant did not address the criticality consequences of this postulated accident in its analysis; in **RAI 647-4651, Question 9.1.1-22** the staff requested that the fuel assembly mislocation criticality analysis be included. In its response dated November 11, 2010, the applicant stated that the calculated neutron multiplication factor, k_{eff}, was lower than 0.6 and the applicant was confident that this was lower than 0.95 without performing sensitivity analyses and applying biases and uncertainties under dry conditions. Based on the staff's evaluation of the applicant's response, the staff considers RAI 9.1.1-22 to be closed.

SRP 9.1.1 states that the applicant should consider the effects of the drop of a fuel assembly on the criticality of the NFRs. The applicant did not address the criticality consequences of this postulated accident in its analysis; in **RAI 647-4651, Question 9.1.1-23** the staff requested that the fuel assembly drop criticality analysis be included. In its response dated November 11, 2010, the applicant provided a brief summary of the mechanical analysis of the dropped assembly and stated that the damaged rack configuration would not increase the k_{eff} calculation. Based on the staff's evaluation of the applicant's response, the staff considers RAI 9.1.1-23 to be closed.

The description outlines the design criteria, evaluation methodology, and assumptions used in the analysis. The results indicate that the multiplication factors are well within the limits set by the acceptance criteria for the conditions in the analysis. The values used to determine Δk_c have been determined in the validation report entitled "Validation of the MHI Criticality Safety Methodology," MUAP-07020, issued December 2007 (Reference 2). The staff has reviewed the results and found that they satisfy the acceptance criteria as described by GDC 62 and 10 CFR 50.68(b).

Spent Fuel and Damaged Fuel Storage

The spent fuel storage racks are contained in a stainless steel-lined concrete reinforced water-filled pool within the Fuel Building. The racks are designed to meet Seismic Category I requirements and therefore remain functional (i.e., maintain fuel in a safe and subcritical array) during a SSE.

The licensee describes the SFR as having a capacity to store 900 spent fuel assemblies, each consisting of a 17x17 bundle consisting of fuel pins, control, and instrumentation guide tubes. The nominal rack pitch is 28.2 cm (11.1 in), and the cell structure material of construction is 304 stainless steel plate. The neutron absorbing material is Metamic^{TM}, which contains 31 percent weight percent B_4C. The Metamic^{TM} sheets are contained in sheathed structures attached to the outside of the storage cells. In addition, the rack design precludes any deformation once it is loaded to capacity, and the inadvertent placement of a fuel assembly on top of the storage rack results in a small perturbation in the overall multiplication factor. The double contingency requirement precludes a dilution accident simultaneously with another accident condition. A DFR is also included in this rack structure. There are 12 such positions, which consist of a stainless steel structure on a pitch of 60.9 cm (24.0 in) that are 55.0 cm (21.7 in) from the SFR. Each position can accommodate one damaged fuel assembly.

The acceptance criterion for meeting the regulatory requirements for verification of subcriticality in the spent fuel storage facility are:

- $K_{eff} \leq 0.95$ under fully loaded, flooded conditions for all normal and credible abnormal conditions.

The staff notes that the licensee does not take credit for burnup in the SFP criticality analysis. As stated in ANSI/ANS 57.2.1983 (Reference 5), it must be demonstrated that criticality could not occur without at least two unlikely, independent and concurrent abnormal occurrences. This double contingency principle is endorsed in the NRC's Memorandum from L. Kopp to T. Collins, "Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at Light Water Reactor Power Plants," dated August 19, 1998. Therefore, concurrent multiple abnormal conditions, such as a pool boron dilution event concurrent with a fuel mislocation condition, need not be considered in the fuel storage rack design.

The SFR criticality analyses performed by the applicant are evaluated in the paragraphs below.

The description outlines the design criteria, evaluation methodology, and assumptions used in the analysis of the SFP. The results indicate that the multiplication factors are well within the limits set by the acceptance criteria, even when flooded with unborated water, for the conditions in the analysis. The uncertainty associated with the placement of the fuel assemblies within the SFR is determined by carrying out calculations for 4, 16, and 36 cells with reflecting boundary conditions. Accidents associated with dropped fuel assemblies are discussed. In addition, mislocated fuel assemblies are also discussed. In the latter case, it is necessary to have 800 ppm of boron added to the pool water to prevent a violation of the criticality requirements (10 CFR 50.68(b)). A misloaded fuel assembly event does not apply in this case as all assemblies are assumed to have fresh fuel of maximum permissible enrichment (percent five weight percent U^{235}). The values used to determine Δk_c have been determined in the validation report entitled "Validation of the MHI Criticality Safety Methodology," MUAP-07020, issued December 2007 (Reference 2). The staff has reviewed the results and found that they satisfy the acceptance criteria as described by GDC 62 and 10 CFR 50.68(b).

Materials and Chemistry Aspects

As stated in NUREG-0800 SRP Section 9.1.1, Subsection III, when credit is taken for neutron absorbing material, its compatibility and chemical stability on the components wetted by water in the SFP and in the new fuel vault should be evaluated. No such materials are present in the new fuel pit, so the evaluation is effectively limited to the SFP. This review includes evaluation of both the materials of construction and the effects of various solutes in the fuel pool water.

The SRP acceptance criteria for compatibility of neutron-absorbing materials with fuel pool water are the relevant sections of ANSI/ANS-57.2 (Reference 5). The EPRI publication, "Pressurized Water Reactor Primary Water Chemistry Guidelines," (Reference 6) represents the principal authority regarding PWR water chemistry, and includes important information regarding fuel pool water, even though not mentioned specifically in GDC 62, or ANSI/ANS-57.2.

Although the staff does not formally review or issue a SE of the various EPRI water chemistry guidelines (including the PWR Primary Water Chemistry Guidelines), the guidelines are recognized as representing industry best practices in water chemistry control. Extensive experience in operating reactors has demonstrated that following the EPRI Guidelines minimizes the occurrence of corrosion related failures. Further, the EPRI Guidelines are periodically revised to reflect evolving knowledge with respect to best practices in chemistry control. Therefore, the staff accepts the use of the EPRI PWR "Primary Water Chemistry Guidelines," as a basis for a recommended primary water chemistry program for a standard reactor design.

A discussion of materials compatibility for the SFP liner and storage racks is contained in the review of SRP 9.1.2. That review also addresses the components of SFP water, which is also relevant to this discussion. This water contains a minimum boric acid (BA) concentration of 4000 ppm, and impurities that are to be limited according to the EPRI Guidelines.

In DCD Section 9.1.1.3.3, the applicant states that neutron absorbing material containing boron will be used in the SFP. In its response to a request for additional information (RAI) (Reference 7), the applicant indicates that Metamic^{TM} is the material of choice. The applicant has no plans to anodize or treat the surface of this material, and cites a number of plants that have been approved by the NRC to use untreated Metamic^{TM}. In addition, it cites several qualification reports by Holtec (all are proprietary), which document resistance of this absorber material to a variety of difficult conditions, including elevated temperature, radiation, and salt or acidic solutions.

A recent test program for Metamic^{TM} was undertaken by the EPRI (Reference 8). The test conditions involved exposing sample coupons to elevated temperatures and radiation doses to simulate long-term use. The conclusions of the study were:

1. Metamic^{TM} appears to be an excellent candidate for both wet and dry spent nuclear fuel storage applications.

2. Metamic^{TM} exhibits exceptional dimensional stability at elevated temperatures and under irradiation. It also largely retains its initial mechanical properties following exposure to elevated temperatures and radiation.

3. The test program has identified the need to chemically clean and/or anodize the surfaces of Metamic^{TM} scheduled for wet storage applications, particularly in the high purity environment of Boiling Water Reactor (BWR) storage pools. Anodized Metamic^{TM} may also be preferred for dry storage applications due to improved emissivity and the resulting positive impact on heat transfer.

4. The 9020-hour accelerated corrosion test has been estimated to be equivalent to ~20 years at 80°F in a typical wet storage scenario. Under these accelerated conditions, very few of the mill finish coupons and none of the anodized coupons in the test matrix experienced a detectable weight loss due to corrosion. Based on the post test condition of the coupons, EPRI expects that coupon weight loss would not be detected even after a simulated 40-year service life.

Based on previous NRC approvals, HOLTEC reports, and the EPRI study, it appears that Metamic^{TM} is a suitable material for the neutron absorbing material. The EPRI report recommends special surface cleaning or anodization; however, the test results motivating this observation were primarily influenced by simulated BWR fuel pools (containing no BA). The simulated PWR pools (containing 2500 ppm BA) produced considerably less corrosion regarding untreated test coupons. Furthermore, corrosion damage to all untreated coupons was minor over the 20-year simulation test. Thus, as long as corrosion is monitored during the life of the plant, the use of untreated Metamic^{TM} is acceptable.

A surveillance program is planned involving test coupons of the neutron absorber material, which are withdrawn periodically from the SFP and examined for corrosion or degradation. While Revision 1 of the DCD provided minimal information, in its response to the RAI information (Reference 7), the applicant provided extensive additional information on its surveillance program. The program consists of 10 test coupons taken from the same lot as the Metamic^{TM} used in construction, and suspended in a location near freshly discharged fuel. The applicant has detailed a schedule and procedure for evaluation of the coupons, spanning a period of 60 years' service life. The evaluation will include visual observation and quantitative measures of coupon size, weight, specific gravity, and neutron attenuation. The schedule also contains increasing time spans between coupon evaluations. The test plan mentions that coupons that do not undergo destructive evaluation, could be replaced back in the SFP. This would allow redundant (multiple) testing and more frequent testing than the current test plan indicates. Finally, the applicant has described corrective actions to be taken if any of the coupons indicate corrosion, swelling, or loss of neutron absorbing properties. In summary, the staff found the surveillance program described by the applicant acceptable because it is based on sound engineering practice and PWR experience, meets the criteria of ANSI/ANS-57.2 (6.4.4.2), and, thus, is sufficient to meet the requirements of GDC 62. The information on the neutron absorbing material and the associated surveillance program was incorporated in Revision 2 of the DCD, Revision 2.

9.1.1.5 Combined License Information Items

There are no COL information items associated with Section 9.1.1 of the US-APWR DCD.

9.1.1.6 Conclusions

The NRC staff has reviewed the criticality safety analyses of the US-APWR new fuel and spent fuel storage rack designs submitted by the applicant in MUAP-07032-P, entitled "Criticality Analysis for US-APWR New and Spent Fuel Storage Racks," issued December 2009 (Reference 1). The staff's review has addressed the methodologies, the fuel storage system design inputs, the criticality safety analysis results, and associated TS.

The fuel storage system includes the new fuel and spent fuel storage racks, and the damaged fuel storage racks.

Based on its review of the applicant's proposed design criteria, design bases, and safety classification of the fuel storage and handling system, the staff concludes that the fuel storage design conforms to the requirements of 10 CFR 50.68 and 10 CFR Part 50, Appendix A GDC 62.

As described in the DCD as supplemented by the associated request for additional information response, the use of Metamic^{TM} as neutron-absorbing material, and the monitoring program using test coupons will maintain the required neutron-absorbing properties in the SFP. If the water chemistry in the SFP is maintained as specified in the DCD, then the neutron absorbing material Metamic^{TM} is sufficiently compatible with SFP water to satisfy the requirements of ANS-57.2, and the EPRI Guidelines. Based on the information summarized above, the staff concludes that the requirements of GDC 62 and GDC 14 have been met.

This conclusion is based on the following:

1. The applicant has met the requirements of GDC 62 pertaining to criticality, because the fuel will remain subcritical under all normal and credible abnormal conditions; and

2. The applicant has met the requirements of 10 CFR 50.68 by compliance with the additional design and analysis requirements specified in 10 CFR 50.68 (b).

3. The applicant has met the requirements of 10 CFR 52.47(b)(1) as there are no ITAAC associated with Section 9.1.1.

9.1.1.7 References

1) Criticality Analysis for US-APWR New and Spent Fuel Storage Racks, MUAP-07032-P, issued December 2009.

2) Validation of the MHI Criticality Safety Methodology, MUAP-07020, issued December 2007.

3) Fuel Storage Racks Criticality Analysis for US-APWR, HI-2094264.

4) X-5 Monte Carlo Team, MCNP - General N-Particle Transport Code, Version 5, LA-UR-03-1987, Los Alamos National Laboratory, issued April 2003, revised October 2005 - MCNP 5.1.40 RSICC Release Notes, LA-UR-05-8617, issued November 2005.

5) ANS, “Design Requirements for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Plants,” ANSI/ANS-57.2-1983, American Nuclear Society, issued October 1983.

6) PWR Primary Water Chemistry Guidelines, Volume 1, Revision 6, Number 1014986, EPRI, issued December 2007.

7) Letter from Yoshiki Ogata to the NRC dated March 30, 2009; Docket No. 52-021; MHI Ref: UAP-HF-09125; Subject: MHI's Responses to US-APWR DCD RAI No. 247-2179 Revision 1; (ADAMS Accession No. ML090910642).

8) Qualification of Metamic for Spent Fuel Storage Application, Technical Report 1003137, EPRI (EPRI Project Manager: A. Machiels), issued October, 2001.

9.1.2 New and Spent Fuel Storage

9.1.2.1 Introduction

The US-APWR design includes facilities for storage of new and spent fuel. The new fuel storage pit includes the fuel assembly storage racks, the concrete storage facility that contains the storage racks, and the auxiliary components. The spent fuel storage pit includes the spent fuel storage racks, the spent fuel storage pool that contains the storage racks, and the associated equipment storage pits.

9.1.2.2 Summary of Application

DCD Tier 1: The DCD Tier 1 information associated with this section is found in Tier 1, Section 2.7.6.1 of the US-APWR DCD for new fuel storage, and Section 2.7.6.2 for spent fuel storage.

DCD Tier 2: The applicant has provided a Tier 2 description of the new and spent fuel storage in Section 9.1.2 of the US-APWR DCD, Revision 3, summarized here in part, as follows:

> The new fuel storage pit is designed to provide support for the new fuel storage rack. It is designed to maintain its structural integrity following a safe-shutdown earthquake (SSE) and to perform its intended function following a postulated event such as fire, internal/external missiles, or pipe break. The structure of the new fuel storage pit supports the weight of the new fuel rack at the floor level. The new fuel rack is shown in Figure 9.1.2-1, “New Fuel Rack Array.” New fuel storage racks store 180 assemblies. The new fuel storage pit is provided with a manually operated drain system, which is connected to the RB sump to prevent the new fuel pit from being flooded by an unanticipated release of water.
>
> The SFP is located within the RB fuel handling area. The facility is protected from the effects of natural phenomena such as earthquakes, winds and tornadoes, floods, and external missiles. The facility is designed to maintain its structural integrity following an SSE and to perform its intended function following a postulated event such as fire. Moderate density racks containing neutron absorbing materials are provided. Spent fuel storage racks are capable of receiving 900 fuel assemblies. The arrangement is shown in Figure 9.1.2.2-1, “Spent Fuel Rack Array.” Penetrations to drain and makeup lines are located to preclude the draining of the SFP due to a break in a line or failure of a pump to stop. A liner leakage collection system is provided to collect possible leakage from liner plate welds on the pit walls and floor. A refueling canal is connected on one side to the SFP. On the opposite side, the refueling canal connects to the spent fuel cask loading pit and to the fuel inspection pit.

ITAAC: The ITAAC associated with a Tier 2 system description is found in Tier 1, Section 2.7.6.1.2 for new fuel storage, and Tier 1, Section 2.7.6.2.2 for spent fuel storage.

TS: The TS associated with Tier 2, Section 9.1.2 are given in Tier 2, Chapter 16, Section 3.7.12 and Section 3.7.13.

9.1.2.3 Regulatory Basis

The relevant requirements of the Commission’s regulations for this area of review, and the associated acceptance criteria, are given in Section 9.1.2 of NUREG-0800, the SRP, and are summarized below. Review interfaces with other SRP sections can be found in Section 9.1.2.I of NUREG-0800.

1. GDC 2 of Appendix A to 10 CFR Part 50, “Design Bases for Protection against Natural Phenomena,” as it relates to structures housing the facility and the facility itself withstanding the effects of natural phenomena like earthquakes, tornadoes, and hurricanes.

2. GDC 4, “Environmental and Dynamic Effects Design Bases,” as it relates to structures housing the facility and the facility itself withstanding the effects of environmental conditions, externally-generated missiles, internally-generated missiles, pipe whip, and jet impingement forces of pipe breaks so safety functions are not precluded.

3. GDC 5, “Sharing of Structures, Systems and Components,” as it relates to shared structures, systems and components (SSCs) important to safety performing required safety functions.

4. GDC 61, “Fuel Storage and Handling and Radioactivity Control,” as it relates to the facility design for fuel storage and handling of radioactive materials, and for the facility design to provide for inspections and testing that is able to verify lack of corrosion in basic structures, no buildup of crud or debris that could impede coolant flow, and no degradation of fixed neutron absorbers.

5. GDC 63, “Monitoring Fuel and Waste Storage,” as it relates to monitoring systems for detecting conditions that could cause the loss of decay heat removal capabilities for spent fuel assemblies, detecting excessive radiation levels, and initiating appropriate safety actions.

6. 10 CFR 20.1101(b), “Radiation Protection Programs,” as it relates to radiation doses kept as low as reasonably achievable (ALARA).

7. 10 CFR 50.68, as it relates to criticality monitoring or design to preclude criticality accidents.

8. 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, the facility has been constructed and will operate in conformity with the COL, the provisions of the Atomic Energy Act of 1954, and the NRC’s regulations.

9. GDC 14, “Reactor Coolant Pressure Boundary,” which relates to maintaining the reactor coolant pressure boundary (RCPB) by controlling Reactor Coolant System (RCS) purity.

Acceptance criteria adequate to meet the above requirements are:

1. Acceptance for meeting the relevant aspect of GDC 2 is based on compliance with Positions C.1 and C.2 of Regulatory Guide (RG) 1.13 , “Spent Fuel Storage Facility Design Basis,” and applicable portions of RG 1.29 , “Seismic Design Classification,” and RG 1.117, “Tornado Design Classification.” For the spent fuel storage facility, additional guidance acceptable for meeting this criterion is found in ANSI/ANS Standard 57.2, Paragraphs 5.11, 5.1.3, 5.1.12.9, and 5.3.2.

For the new fuel storage facility, additional guidance acceptable for meeting this criterion is found in ANSI/ANS 57.3, Paragraphs 6.2.1.3(2), 6.2.3.1, 6.3.3.4, and 6.3.4.2.

2. Acceptance for meeting the relevant aspect of GDC 4 is based on Positions C.2 and C.3 of RG 1.13, RG 1.115, and RG 1.117.

3. GDC 5 is met by sharing the SSCs important to safety between the units in a manner that does not degrade the performance of their safety functions.

4. Acceptance for meeting the relevant aspect of GDC 61 for the spent fuel storage facility is based on compliance with Positions C.4, C.6, C.10, C.11 and C.12 of RG 1.13 and the appropriate paragraphs of ANS 57.2. Acceptance for meeting this criterion for the new fuel storage facility is based on compliance with the appropriate paragraphs of ANS 57.3. Acceptance is also based on meeting the fuel storage capacity requirements noted in Subsection III.1 of SRP Section 9.1.2.

5. Acceptance for meeting the relevant aspect of GDC 63 for spent fuel storage is based on compliance with Position C.7 of RG 1.13 and Paragraph 5.4 of ANS 57.2. Acceptance for meeting this criterion for the dry storage of new fuel is based on radiation monitoring pursuant to 10 CFR 70.24 or acceptable prevention of an increase in effective multiplication factor (K_{eff}) beyond safe limits as described in 10 CFR 50.68.

6. In meeting the provisions of 10 CFR 20.1101(b), Positions C.2.f(2) and C.2.f(6) of RG 8.8 , “Information Relevant To Ensuring That Occupational Radiation Exposures At Nuclear Power Stations Will Be As Low As Is Reasonably Achievable,” are the bases for acceptance with respect to provisions for decontamination. For spent fuel storage, Paragraph 5.1.5 of ANS 57.2 and appropriate positions of RG 1.13 are the bases for acceptance. For new fuel storage, Paragraphs 6.3.3.7 and 6.3.4 of ANS 57.3 are the bases for acceptance.

7. 10 CFR 50.68 allows the applicant to follow the guidelines of 10 CFR 70.24 for criticality monitors or the guidance described therein for significant margins of subcriticality.

The SRP Acceptance Criteria related to the compatibility of SFP materials with coolant listed in SRP Section 9.1.2 are:

1. The relevant sections of RG 1.13. (Reference 1)

2. Relevant sections of ANS 57.2. (Reference 2)

3. The EPRI publication, *Pressurized Water Reactor Primary Water Chemistry Guidelines* (Reference 3), which represents a principal authority regarding PWR water chemistry, and includes useful information regarding fuel pool water. The EPRI Guidelines are mentioned in SRP 9.3.4 as a means to satisfying the requirements of GDC 14. Even though the SFP is independent of the RCS during normal operation, this requirement is relevant since the SFP water enters the RCS during refueling.

Although the staff does not formally review or issue a safety evaluation of the various EPRI water chemistry guidelines (including the *PWR Primary Water Chemistry Guidelines*), the guidelines are recognized as representing industry best practices in water chemistry control. Extensive experience in operating reactors has demonstrated that following the EPRI Guidelines minimizes the occurrence of corrosion related failures. Further, the EPRI Guidelines are periodically revised to reflect evolving knowledge with respect to best practices in chemistry control. Therefore, the staff accepts the use of the EPRI *PWR Primary Water Chemistry Guidelines* as a basis for a recommended primary water chemistry program for a standard reactor design.

9.1.2.4 Technical Evaluation

The staff has reviewed the US-APWR advanced reactor's new and spent fuel storage facility, as presented in the DCD, Revision 3, Section 9.1.2, "New and Spent Fuel Storage, in accordance with the guidance NUREG-0800, "Standard Review Plan" Section 9.1.2, "New and Spent Fuel Storage," Revision 4 dated March 2007.

SRP Section 9.1.2

In DCD Tier 2, Section 9.1.1.1, "Design Bases," the applicant states that the new fuel will be stored in a low-density rack without neutron-absorbing material. The rack includes storage locations for 180 fuel assemblies. The rack array will have a center-to-center spacing of 43 cm (16.9 in). This spacing provides separation between adjacent fuel assemblies that is sufficient to maintain a subcritical array, even if the building is flooded with unborated water or optimum moderation. Additionally, the rack design doesn't allow for fuel bundles to be inserted between cells. The dry, unlined, approximately 5.5 meters (18 ft.) deep, reinforced concrete pit is designed to support the new fuel storage rack. The new fuel pit will normally be covered to prevent foreign objects from entering the new fuel storage rack.

In DCD Tier 2, Section 9.1.2, "New and Spent Fuel Storage," the applicant states that the spent fuel will be stored in moderate-density racks within the SFP that include neutron-absorbing material to maintain the required degree of subcriticality. The rack arrays will have a center-to-center spacing of 28.2 cm (11.1 in.) and storage locations for 900 fuel assemblies. This is enough storage for 10 years of full power operation. In addition, a separate rack will be provided with an array of 12 storage spaces for damaged fuel assembly containers. This array does not contain the neutron absorber and the center-to-center spacing of this array is 60.1 cm (24 in).

SRP Section 9.1.2 recommends that the minimum storage capacity should be equal to or exceed the amount of spent fuel from 5 years of operation at full power plus one full-core discharge.

Based on the above, the staff finds that the applicant has adequately defined the new and spent fuel storage design within the US-APWR DCD, which is consistent with the recommendations of SRP Section 9.1.2.

GDC 2

In DCD Tier 2, Section 9.1.2.3, the applicant states that the new fuel and spent fuel storage racks and the pits are designed as seismic Category I. Also, in DCD Tier 2, Section 9.1.1.1, the applicant states that the new and spent fuel storage facilities are designed to meet the guidelines of ANS 57.2 and ANS 57.3, and are located in the fuel handling area of the RB, which is a seismic Category I structure. The RB is also designed against flooding and tornado missiles.

In DCD Tier 2 Table 3.2-2, "Classification of Mechanical and Fluid Systems, Components, and Equipment," and Table 3.2-4, "Seismic Classification of Buildings and Structures," provide the safety classification, seismic classification, quality group classification, applicable commercial codes and locations for the new and spent fuel facility SSCs. The staff finds that the safety classification, quality group, seismic category and location for the new fuel and spent fuel storage racks are properly designated. The staff also finds that the new and spent fuel storage facility is also designed to ensure that failure of any nonsafety-related portions of the facility does not compromise any safety function of the new fuel and spent fuel storage.

The new fuel pool (NFP) and the SFP are designed with Seismic Category I walls that protect the fuel against missiles and external conditions. Additionally, these facilities are located inside the RB, which is a seismic Category I structure that provides protection. The staff evaluation of the design of the fuel building to provide protections against flooding, missiles, and seismic events is addressed in other sections of this SE.

> Section 3.4.1 of this SE addresses the staff's evaluation of flood protection provided for SSCs which are important to safety.
>
> Section 3.5.1.1 of this SE addresses the staff's evaluation of protection provided for SSCs which are important to safety from internally generated missiles outside containment.
>
> Section 3.5.1.3 of this SE addresses the staff's evaluation of protection provided for SSCs which are important to safety from missiles generated turbine.
>
> Section 3.5.1.4 of this SE addresses the staff's evaluation of protection provided for SSCs which are important to safety from missiles generated by natural phenomena.
>
> Section 3.5.2 of this SE addresses the staff's evaluation of protection provided for SSCs which are important to safety from externally generated missiles.
>
> Section 3.8 of this SE addresses the staff's evaluation of the structure design including new fuel and spent fuel storage facilities including fuel storage racks.

Based on the seismic classification of the new fuel and spent fuel storage facilities SSCs discussed above, and the staff's evaluation of the RBs capability to withstand natural phenomena, as discussed in Sections 3.4.1, 3.5.1.1, 3.5.1.3, 3.5.1.4, 3.5.2 and 3.8 of this SE, the staff finds that the new fuel and spent fuel storage facilities including fuel storage racks have met the relevant requirements of GDC 2 by demonstrating compliance with positions C.1 and C.2 of RG 1.13 and applicable portions of RG 1.29, RG 1.117, ANS 57.2 and ANS 57.3.

GDC 4

As discussed above, the NFP and the SFP are designed with seismic Category I walls that protect the fuel from internal and external generated missiles, and from pipe breaks. In DCD Tier 2, Section 9.1.2.2, the applicant states that the fuel handling building does not contain credible sources of missiles, and the walls of the fuel handling building protect the storage facilities from missiles generated inside the RB.

Section 3.6.1 of this SE addresses the staff's evaluation of the design of structures, shields, and barriers required for the protection of safety related SSCs against dynamic effects of high-energy line breaks, including the protection of the new fuel and spent fuel storage facilities SSCs.

Based on the staff evaluation of the seismic classification of the NFP and the SFP walls discussed above, the protections against pipe failures discussed in Section 3.6.1 of this SE and the staff evaluation of the design of the RB to protect against missiles, the staff finds that the new fuel and spent fuel storage facilities are protected against the effects of, and are compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents. The staff, therefore, determines that the new fuel and spent fuel storage facilities meet the requirements of GDC 4.

GDC 5

The US-APWR standard plant design is a single-unit station; therefore, the requirements of GDC 5 are not applicable to the US-APWR standard plant design.

GDC 61

In DCD Tier 2, Section 9.1.2.3 the applicant provides a safety analysis to demonstrate that the new fuel and spent fuel storage rack design complies with the design criteria stated in SRP Section 9.1.2. In the safety analysis, the applicant considered normal and postulated accident conditions, such as flooding the new fuel pit with pure water and optimum moderator. In addition, the applicant states that the following design features will minimize the possibility of accidents:

- Travel limits on handling equipment capable of carrying loads heavier than fuel components (described in DCD Tier 2 Section 9.1.5)
- Racks designed as seismic Category I structures
- Racks designed for dropped fuel assembly (and handling tool) conditions
- New fuel storage pit cover to protect new fuel from dropped objects and debris
- Racks designed to withstand uplift forces from overhead cranes (described in DCD Tier 2 Section 9.1.2.2.3)

Also, the applicant stated that heavy loads are prevented from being lifted over the SFP and the fuel racks are designed to withstand a load drop equivalent to that from a fuel assembly and its associated handling tool when dropped from its operating height.

Section 9.1.4, "Light Load Handling System," of this SE addresses the staff's evaluation of accident considerations during light load handling.

Section 9.1.5, “Overhead Heavy Load Handling System,” of this SE addresses the staff’s evaluation of accident considerations during overhead heavy load handling.

SRP Section 9.1.2, III.1 recommends the use of low-density storage racks for the most recently discharged fuel. However, Section 9.1.2.1 of the DCD Tier 2 states that the spent fuel is stored in moderate density storage racks which provide adequate natural coolant circulation to remove the residual decay heat. In RAI 132-1538, Question 9.1.2-2, the staff requested the applicant to justify in the DCD, why moderate density storage racks are used instead of the low density racks as the SRP recommends. In its RAI response dated January 29, 2009, the applicant justified its departure from the SRP recommendations by citing many other current and new reactor designs that have been approved by the NRC for moderate density storage rack systems. The applicant also provided a thermal analysis report (Thermal-Hydraulic Analysis for US-APWR Spent Fuel Racks, issued June 2009, Technical Report MUAP-09014P) that provides conservative calculations to justify its design and to demonstrate that it meets the appropriate requirements. The staff found the applicant’s analysis demonstrated that the proposed moderate density rack is capable of providing adequate natural circulation of coolant through the racks and meets all the applicable requirements; therefore the staff considers its concerns as described in RAI 132-1538, Question 9.1.2-2, to be resolved.

In DCD Section 9.1.2.1, the applicant stated that drains are provided to prevent the flooding of the NFP. SRP Section 9.1.2, Section III.2.L states that a dry new fuel storage vault drain should be sized to handle the maximum flow from the rupture of the largest water pipe in the area. The drain sizing criteria were not addressed within the DCD. In RAI 132-1538, Question 9.1.2-3, the staff requested the applicant to include in the DCD the sizing criteria for the NFP drains and to discuss how the design of these drains meet the design criteria discussed in SRP Section 9.1.2, Section III.2.L. In its RAI response dated January 29, 2009, the applicant stated that the NFP is design with a dyke that surrounds the pit and prevents water from entering. The NFP is also designed with a drain system that is capable of handling the maximum water flow from a pipe failure in the NFP area. The applicant also stated that criticality analysis conservatively assumes a flooded NFP, and thus the drain system is credited for the prevention of criticality. The staff found the applicant’s clarification that the drain system is capable of handling the maximum water flow from a pipe failure in the NFP area to be acceptable. Therefore, the staff considers its concerns as described in RAI 132-1538, Question 9.1.2-3, to be resolved.

SRP Section 9.1.2, Section III.2.L states that backflow into a dry new fuel vault through the drain system needs to be prevented. DCD Tier 2 Section 9.1.2.2.1 stated that the design of the manually operated drain piping system prevents backflow into the new fuel pit storage area through the drain system. It was unclear to the staff, how the manually operated drain piping system would be able to provide flooding protection and backflow protection at the same time. In RAI 132-1538, Question 9.1.2-4, the staff requested the applicant to justify how the manually operated drain piping system will be able to provide flooding protection and backflow protection at the same time, why no automatic backflow protection device (for example, a check valve) is needed, and why there are no ITAAC requiring the testing of the proper function of the backflow protection measures.

In its RAI response dated January 29, 2009, the applicant stated that the DCD description of the drain valve was incorrect. The applicant proposed to modify the DCD to better describe the operation of the valve. Detailed changes were proposed for both Tier 1 and Tier 2 sections of the DCD where the valve will be described as a check valve and its function will be verified by the existing ITAAC items. The staff found the proposed use of a check valve to prevent back-flow of water into the new fuel pit storage area through the drain system to be acceptable. The staff reviewed Revision 2 of the DCD and confirmed that it contains the proposed changes described in the response to RAI 132-1538, Question 9.1.2-4. Revision 3 of the DCD introduced several changes to Tier 1. The staff evaluated these new changes and determined that they were adequate to demonstrate that the drain system was constructed with means that would prevent back-flow of water into the new fuel pit storage area through the drain system. Therefore the staff considers its concerns as described in RAI 132-1538, Question 9.1.2-4, to be resolved.

SRP Section 9.1.2, Section III.2.J states that the dry new fuel storage racks should be designed with openings at the bottom to facilitate drainage if intended for dry storage or flooding if intended for wet storage. These design considerations were not discussed within the DCD, and the drawings of the new fuel storage rack were not of sufficient detail to determine if these design criteria were met. In RAI 132-1538, Question 9.1.2-5, the staff requested the applicant to include in the DCD, the additional design considerations for the sizing of the orifice on the bottom of the new fuel storage racks. In its RAI response dated January 29, 2009, the applicant described the storage rack drain holes as similar to those in the spent fuel storage racks. Section 9.1.2.2.1 in the DCD, Revision 2 submittal, describes this feature of the new fuel storage racks. The staff finds these modifications to the DCD acceptable because DCD Tier 2, Section 9.1.2.2.1 includes a description of the sizing criteria of the drain orifice on the bottom of the new fuel racks that is consistent with the recommendations of the SRP. Therefore the staff considers its concerns as described in RAI 132-1538, Question 9.1.2-5, to be resolved.

SRP Section 9.1.2, Section II states that the applicant should establish provisions for inspection and testing to verify that there is no corrosion of the fuel racks and SFP liner. It further states that cooling channels should be inspected to assure they are free of crud or debris. In Tier 2 Section 9.1.2.2.2, the applicant described the proposed surveillance program that will be employed to monitor the long-term stability and mechanical integrity of the spent fuel rack poison. However, the applicant had not identified the inspection program for the spent fuel storage racks and the SFP liner. In RAI 132-1538, Question 9.1.2-6, the staff requested the applicant to include, in the DCD, a description of the inspection program for the spent fuel storage racks and the SFP liner. In its RAI response dated January 29, 2009, the applicant stated that a scheduled formal inspection plan was not necessary due to the large areas available for coolant flow. The applicant further stated that inspections will informally occur upon every visit of plant personnel to the area. The staff has determined that the rate of crud buildup is difficult to predict in this design phase for it is dependent upon local water chemistry. Since the NRC does not allow credit for informal inspections, a formal inspection program should be instigated. Therefore, the staff determined that this RAI response had not addressed all the staff’s concerns. The staff issued supplemental RAI 387-2931, Question 9.1.2-21 to request the applicant to justify why it cannot comply with the recommendations of SRP Section 9.1.2 involving a formal inspection program for the SFP.

In its RAI response dated July 10, 2009, the applicant proposed to create a new COL information item instructing the COL applicant to establish procedures to instruct the operator to perform formal inspections of the spent fuel rack integrity. The staff determined that the creation of this COL information item is in accordance with the SRP recommendations and is therefore considered to be acceptable. The staff reviewed Revision 2 of the DCD and confirmed that it contains the revisions described in the applicant’s response to Supplemental RAI 387-2931, Question 9.1.2-21. Therefore, the staff considers its concerns as described in RAI 132-1538, Question 9.1.2-6 and Supplemental RAI 387-2931, Question 9.1.2-21, to be resolved.

SRP Section 9.1.2, Section III.2.H.i states that the bottom of any transfer gate should be above the top of the fuel assemblies, and that the volume of the adjacent fuel-handling areas should be limited so that leakage into these areas would not reduce the coolant inventory to less than three meters (10 feet) above the top of the fuel assemblies. However, the staff determined that the applicant had not provided enough detail to evaluate if these guidelines are met. The staff also found that the applicant had not proposed an ITAAC to verify the proper construction of the gates. In RAI 132-1538, Question 9.1.2-7, the staff requested the applicant to specify in the DCD, and verify by an ITAAC, that the bottom of the fuel transfer gate is located above the stored fuel assemblies, to determine the impact of any transfer gate failure on the SFP water level (water level drop), and to include these results in the DCD.

In its RAI response dated January 29, 2009, the applicant provided more details regarding the SFP and adjacent fuel handling areas, and included revised drawings to illustrate the calculations. Based on a calculation, the applicant concluded that flooding of adjacent areas will not uncover the spent fuel elements. The applicant's response also proposed to revise Tier 1, Section 2.7.6.2.1, of the DCD, so that the weir elevation of the gates is verified to be above the top of the stored spent fuel in accordance with the SRP recommendations. The staff determined that the SFP and adjacent areas comply with the recommendations of SRP Section 9.1.2. However, Revision 3 of the DCD introduced several changes to Tier 1 that modified the changes proposed in response to RAI 132-1538, Question 9.1.2-7. The staff evaluated the new changes to Tier 1 Section 2.7.6.2.1 and found these changes acceptable, as they related to the staff concerns as expressed in RAI 132-1538, Question 9.1.2-7. Therefore, the staff considers its concerns as described in RAI 132-1538, Question 9.1.2-7, to be resolved.

DCD Tier 2 Section 9.1.2.2.2 states that the pipes that discharge into the SFP are designed with anti-siphon devices to prevent the unanticipated draining of the SFP. This design feature is consistent with the recommendations of SRP Section 9.1.2. However, the staff determined that the applicant had not proposed an ITAAC to verify the proper construction and operation of the anti-siphon devices. In RAI 132-1538, Question 9.1.2-8, the staff requested the applicant to create an ITAAC to verify the proper construction and operation of the anti-siphon devices. In its RAI response dated January 29, 2009, the applicant provided more details about the anti-siphon features of the design and proposed to revise portions of DCD Tier 1 and Tier 2 (Figure 9.1.3-1). The proposed changes allowed incorporation of the anti-siphon function into an existing ITAAC (Table 2.7.6.3-5 Item 1) to assure that these features are verified. However, in Revision 3 of the DCD, the applicant revised the wording of ITAAC 2.7.6, including the proposed wording described in the response to RAI 132-1538, Question 9.1.2-8. The staff evaluated the changes introduced in Revision 3 of the DCD and determined that these new changes were acceptable because the verification of the anti-siphon function was included into ITAAC 2.7.6.2.1. Therefore, the staff considers its concerns as described in RAI 132-1538, Question 9.1.2-8, to be resolved.

SRP Section 9.1.2, Section III.2.I states that the applicant should show, via a thermal-hydraulic analysis of the SFR, that the cooling is adequate for decay heat removal from the spent fuel assemblies during all anticipated operating and accident conditions. The heat removal processes should avoid nucleate boiling within the SFP and openings in the rack floor should be large enough to allow the natural circulation of coolant. This heat transfer analysis was not provided within the DCD. In RAI 132-1538, Question 9.1.2-9, the staff requested the applicant to provide this thermal hydraulic analysis and to include in the DCD, the thermal analysis assumptions, inputs, and conclusions [including the sizing criteria for the orifices in the rack floor]. In June 2009, the applicant submitted the thermal analysis report that concluded that the SFP racks were designed with openings that allow proper water circulation through the racks.

The staff evaluated the analysis and concluded that the analysis demonstrates that the racks are designed with sufficient flow area through the bottom plate to allow natural circulation of water to cool the stored assemblies and prevents departure from nucleate boiling. Therefore, the staff finds the applicant's RAI response to be acceptable and RAI 132-1538, Question 9.1.2-9 is considered to be resolved.

Due to subsequent design changes, the applicant is revising the structural and seismic design of the SFP. In RAI 806-5985, Question 9.1.2-25, the staff requested the applicant to provide an updated thermal analysis report that would demonstrate that the SFR have been designed to provide adequate natural circulation of the coolant. In an RAI response dated September 2, 2011, the applicant stated that the applicable thermal analysis report for the chosen rack design is the previously submitted "Thermal-Hydraulic Analysis for US-APWR Spent Fuel Racks," issued June 2009, (Technical Report MUAP-09014P). The staff concluded that, since the reference thermal analysis remains to be MUAP-09014P, the applicant's response is acceptable and the staff considers RAI 806-5985, Question 9.1.2-25, to be resolved.

However, the applicant identified that DCD Tier 2, Section 9.1.3.3.2, incorrectly refers to Reference 9.1.3-26 when it should refer to Reference 9.1.7-26. The applicant proposed to incorporate this correction in future updates of the DCD. The staff is tracking the resolution of this item as **Confirmatory Item 9.1.3-26.**

SRP Section 9.1.2, Section III.2.B states that improper loading of fuel elements should be avoided. The DCD Tier 2, Section 9.1.2, states that the design of the NFR prevents the improper loading of fuel elements. The staff could not confirm that the SFRs had been designed to prevent improper loading of fuel elements. It was unclear how the accidental loading of a fuel assembly into an improper location is avoided in the US-APWR design for either fuel rack system. Improper loading can result in accidental criticality and reduced cooling. In RAI 132-1538, Question 9.1.2-10, the staff requested the applicant to include in the DCD, a description of how this condition is avoided. In its RAI response dated January 29, 2009, the applicant explained how the precise indexing of the fuel handling machine prevents the improper loading of fuel elements into the storage racks. The RAI response stated that detailed operation of the fuel handling machine is described in the DCD Tier 2, Section 9.1.4.2.1.1 and Section 9.1.4.2.1.2. Section 9.1.4 of this SE addresses the staff's evaluation of how the precise indexing of the fuel handling machine prevents the improper loading of fuel elements into the storage racks. The staff found the applicant's response to RAI 132-1538, Question 9.1.2-10 acceptable because it clarifies how the applicant prevents improper loading of fuel elements. Therefore, the staff considers its concerns as described in RAI 132-1538, Question 9.1.2-10, to be resolved.

SRP Section 9.1.2, Section III.3.B states that, if the SFP liner plate is not designed and constructed to seismic Category I requirements, the SFP liner plate is reviewed for whether a failure of the liner plate, as a result of a SSE, will not cause any of the following:

- Significant releases of radioactivity due to mechanical damage to the fuel.
- Significant loss of water from the pool, which could uncover the fuel and lead to release of radioactivity due to heat-up.
- Loss of ability to cool the fuel due to flow blockage caused by a complete section or portion of the liner plate falling on the fuel racks.

- Damage to safety-related equipment as a result of pool leakage.

- Uncontrolled release of significant quantities or radioactive fluids to the environs.

The DCD did not clearly state the seismic classification of the SFP liner. The staff also noted that the applicant had not proposed an ITAAC to verify the proper construction of the SFP liner. In RAI 132-1538, Question 9.1.2-11, the staff requested the applicant to clarify in the DCD that the SFP liner was designed as a seismic Category I structure or to include in the DCD a justification (that addresses all the elements mention above) that explains why the SFP liner was not designed as a seismic Category I structure. The staff also requested the applicant to justify why there is no ITAAC to verify the proper construction of the SFP liner (leak tight). In its RAI response dated January 29, 2009, the applicant clarified that the SFP liner is designed as a seismic Category I structure. In addition, the applicant proposed to revise the Tier 1 (Section 2.7.6.2.1) and Tier 2 (Section 9.1.2.2.2) DCD to clearly state that the SFP liner is designed as a seismic Category I structure. Since this clarification makes the SFP liner subject to ITAAC verification and assures that the liner will be built to appropriate design standards, the staff considers the applicant's response to RAI 132-1538, Question 9.1.2-11, to be acceptable.

However, in Revision 3 of the DCD, the applicant revised Tier 1 Section 2.7.6.2.1 and deleted references to SFP liner seismic classification. In a letter dated June 7, 2011, the applicant revised its response to RAI 132-1538, Question 9.1.2-11, and stated that the SFP liner is classified as a seismic Category I structure and, therefore, its design is addressed in DCD Tier 2 Section 3.8.4. The applicant also stated that COL applicants must establish an in-service inspection and testing program for Seismic Category I structures, as described in Section 3.8.3.7 and Section 3.8.4.7 of the DCD. The staff evaluated the applicant's response and determined that the revised response still classifies the SFP liner as a Seismic Category I component. Since the applicant moved the evaluation of the liner seismic classification into DCD Tier 2 Section 3.8.4, all the staff's concerns, as described in RAI 9.1.2-11, are addressed. Therefore, RAI 132-1538, Question 9.1.2-11 is considered to be resolved. The staff's evaluation of DCD Tier 2 Section 3.8.4 is addressed in Section 3.8.4 of this SE.

SRP Section 9.1.2, Section III.2.A states that the SFP liner should be designed to withstand all design basis loads. The staff identified that DCD Tier 2 Section 9.1.2 has not addressed this design recommendation and it is not listed as an ITAAC design feature to be verified in Tier 1 Section 2.7.6.2. In RAI 132-1538, Question 9.1.2-12, the staff requested the applicant to discuss in the DCD, the SFP liner capacity to withstand all design basis loads. In its RAI response dated January 29, 2009, the applicant explained that the SFP liner is designed as a seismic Category I structure and thus, is subject to a variety of design basis loads. The response also proposed modifications to the Tier 1 and Tier 2 DCD to describe this classification and specify the loads that the liner is designed to withstand. The applicant stated that the leak-tightness of the liner will be demonstrated by the verification program.

However, in Revision 3 of the DCD the applicant revised Tier 1 Section 2.7.6.2.1 and deleted references to SFP liner seismic classification. In a letter dated June 7, 2011, the applicant revised its response to RAI 132-1538, Question 9.1.2-11. In its revised response, the applicant stated that the SFP liner is classified as a Seismic Category I structure and, therefore, its design is addressed in DCD Tier 2 Section 3.8.4. The revised response also states that the liner will maintain its structural integrity and will remain leak tight under all design basis loads. These loads include dead, live, hydrostatic, hydrodynamic, seismic, normal operation, accidental thermal and spent fuel assembly drop.

The staff reviewed the applicant's revised response dated June 7, 2011, and confirmed that the SFP liner is designed to withstand all the expected loads, as recommended by SRP Section 9.1.2, Section III.2.A; therefore, the staff considered its concerns as described in RAI 132-1538, Question 9.1.2-12, to be resolved.

The applicant's design incorporates a filtration system in the RB to minimize any radionuclide release in case of an accident involving spent fuel. This is consistent with the recommendations of SRP Section 9.1.2.

Section 9.4.3 of this Safety Evaluation (SE) addresses the staff's evaluation of the AB Heating Ventilation and Air Conditioning (HVAC) system, which serves the RB.

Based on the above discussion, the staff finds that the fuel handling facility design is in compliance with the recommendations of SRP Section 9.1.2, and therefore meets the requirements of GDC 61.

GDC 63

In the DCD Tier 2 Section 9.1.2.2.2 the applicant describes the leakage collection system for the SFP. This system is monitored to determine whether leakage is occurring. However, the applicant did not provided sufficient details of the collection system to allow the staff to evaluate the system. The applicant did not define a monitoring schedule and the capacity of the collection system. In addition, the applicant did not describe how or how often this system will be tested to ensure its proper operation. In RAI 132-1538, Question 9.1.2-13, the staff requested the applicant to include in the DCD, a detailed description of the SFP liner leakage collection system monitoring schedule, system capacity, how system operability is evaluated, and what the testing intervals are. In its RAI response dated January 29, 2009, the applicant described, in detail, the SFP liner leakage detection system. In the RAI response, the applicant also proposed modifications to the DCD to describe the leakage collection system in detail, including how the liner leakage is collected and monitored. The staff finds the proposed DCD changes to be in accordance with the recommendations of SRP Section 9.1.2, and therefore, is considered to be acceptable. The staff reviewed Revision 2 of the DCD and confirmed that it contains the revisions described in the applicant's response to RAI 132-1538, Question 9.1.2-13. Therefore the staff considers its concerns as described in RAI 132-1538, Question 9.1.2-13, to be resolved.

DCD Section 9.1.2.2.2, states that SFP water level and temperature gauges, and an area radiation monitor in the fuel handling area are provided with alarms to the main control room (MCR). DCD Tier 1 Section 2.7.6.2, "Spent Fuel Storage," states that the SFP liner leakage collection system is provided with a leak detection capability and that there are no other alarms, displays, or controls associated with the spent fuel storage facilities. The staff found these two statements to be contradictory; additionally, neither of these two Sections is in accordance with the recommendations given by SRP Section 9.1.2. In RAI 132-1538, Question 9.1.2-14, the staff requested the applicant to clarify in the DCD what the monitoring requirements for the SFP are and to justify in the DCD why the US-APWR design is not in accordance with the recommendations of SRP Section 9.1.2. In its RAI response dated January 29, 2009, the applicant stated that the SFP water level, water temperature and radiation monitors are provided with alarms both in the Main Control Room (MCR) and locally. In the RAI response, the applicant also proposed changes to DCD Tier 2 Section 9.1.2.2.2 and Figure 9.1.2-1, entitled "New Fuel Rack Array," and Tier 1, Section 2.7.6.2.1 that clearly outline how the alarm signal is received in the MCR and locally. The Tier 1 modification also identifies the radiation alarms included in the design of the spent fuel storage facility. However, in Revision 3 of the DCD the applicant revised Tier 1 Section 2.7.6.2.1 and deleted references to SFP level and temperature. In a letter dated June 7, 2011, the applicant revised the response to RAI 132-1538, Question 9.1.2-14. In its revised response the applicant clarified that the SFP level and temperature were not classified as safety-related parameters and, therefore, following the guidance provided in SRP Section 14.3, did not meet the criteria to be included in the ITAAC. The applicant's response adds that the SFP level, temperature, and area radiation are monitored in the MCR and are set to alarm, both locally and in the MCR. DCD Tier 2 Section 14.2.1 describes verification of these functions by performing preoperational testing 14.2.12.1.85, "Spent Fuel Pit Cooling and Purification System."

The staff reviewed the changes introduced in DCD Revision 3 and the justification provided in the revised response to RAI 132-1538. Question 9.1.2-14, and the staff found that although the alarms mentioned in the RAI response are not classified as safety-related, the alarms exist locally and in the MCR and will be capable of alerting the operators of abnormal or unsafe conditions. Based on this, the staff finds the applicant's response acceptable, since the design of the alarms meets the recommendations of SRP 9.1.2. Therefore the staff considers its concerns as described in RAI 132-1538, Question 9.1.2-14, to be resolved.

Based on its review, the staff finds that the fuel handling facility design is in compliance with the recommendations of SRP Section 9.1.2 and, therefore, the design meets the requirements of GDC 63.

Coolant Chemistry

As recommended in SRP Section 9.1.2, the staff has reviewed the compatibility of SFP materials with coolant. This review includes evaluation of both the materials of construction (composition and preparation) and the concentrations and effects of various solutes in the fuel pool water.

Spent Fuel Storage

The DCD mentions that the liner of the SFP is stainless steel, consistent with the requirements of ANS-57.2 (Section 6.1.2.10). All internal components of the cooling and purification system are also stainless steel, and are discussed in the review of SRP 9.1.3. The SFRs themselves are constructed of stainless steel and use borated neutron absorbing materials between the assemblies. These are discussed in more detail in the review of SRP 9.1.1.

In its response to RAI 248-2178, Question 9.1.2-18 (Reference 4),dated March 30, 2009, the applicant has stated that the liner surface has a 2B finish or higher, and will be smooth and non-porous. These qualities should provide good resistance to corrosion, and facilitate decontamination as required by ANS-57.2. Also, in its response to RAI 389-2919, Question 9.1.2-24 (Reference 5), dated July 14, 2009, the applicant has stated that the surface finish has smoothness consistent with the requirements of ANS-57.2, and that the DCD will be modified to include this information. The staff has verified that both of these changes have been made in Revision 2 of the DCD.

As the SFP is interconnected to the refueling water storage pit (RWSP), the water chemistry of the two should be considered equivalent. This water contains a minimum BA concentration of 4000 ppm. The EPRI Guidelines recommend that chloride, fluoride, and sulfate be limited, since excess amounts of these solutes can contribute to the degradation of fuel pool and fuel bundle materials. As mentioned above, the SFP water will enter the RCS during refueling operations; thus, it is essential that these contaminants be controlled. The EPRI Guidelines also recommend monitoring of silica and fission products ("gamma isotopics"), although no limits are specified. The sampling frequency for all quantities in the EPRI Guidelines is recommended to be monthly. From DCD Table 9.1.3-1, the limiting concentrations of chloride and fluoride are identical to the values stated in the EPRI Guidelines. In its response to RAI 248-2178, Question 9.1.2-19 (Reference 4), dated March 30, 2009, the applicant has also included limits for sulfate, silica, and turbidity, and noted that gamma isotopics will be sampled continuously. It has also mentioned sampling frequencies for all quantities that meet or exceed the recommendations of the EPRI Guidelines. The applicant noted that DCD Table 9.1.3-1 would be changed to reflect this information, and the staff has verified that DCD Revision 2 does reflect these changes.

Neutron absorber materials are used in the SFP. The applicant intends to use Metamic, as reported in the response to RAI 247-2179 Revision 1, Question 9.1.1-9. In addition, the staff has verified that Revision 2 of the DCD mentions use of Metamic as the intended neutron absorber. The integrity of this material is evaluated in the review of SRP Section 9.1.1. A surveillance program is planned involving test coupons, which are withdrawn periodically from the SFP and examined for corrosion or degradation. While such a surveillance program does not directly examine the SFP liner or rack materials, it should prove useful in identifying corrosion that might occur in these stainless steel structures.

New Fuel Storage

The new fuel storage pit is a dry concrete room, with drainage to limit water intrusion. The DCD states that all surfaces that contact fuel assemblies are made of annealed austenitic stainless steel. It also states that rack materials generally are corrosion resistant, and compatible with the storage pit environment, although no details are supplied in the DCD. In its response to RAI 248-2178, Question 9.1.2-20 (Reference 4), dated March 30, 2009, the applicant notes that racks are made of austenitic stainless steel and that there are no credible means by which corrosives would be introduced into this area. The staff finds this response acceptable since the applicant has supplied sufficient information to provide reasonable assurance that GDC 61 will be met for the new fuel storage racks, with respect to minimizing corrosion.

As Low As Reasonably Achievable

The SFP is designed with sufficient depth to provide at least 3 m (10 feet) of water coverage while handling fuel to provide adequate shielding to the operators. Additionally, the volume of the adjacent pools was evaluated to ensure that if there is a gate failure, the SFP will maintain over 3 m (10 feet) of water coverage over the stored fuel.

The staff evaluated these design features and found them to be in accordance with the recommendations of SRP Section 9.1.2, and therefore, the staff considers them to be acceptable. A more detailed evaluation of the operational radiation protection program and radiation protection design features provided to assure that occupational radiation exposures(OREs) are ALARA as required in 10 CFR 20.1101(b) is addressed in Section 12.0 of this SE.

Inspections, Tests, Analyses, and Acceptance Criteria

Tier 1 Section 2.7.6.1 and Section 2.7.6.2, define a number of ITAAC items related to new and spent fuel storage. ITAAC 2.7.6.1-2 and ITAAC 2.7.6.2-2 require that the new and spent fuel system design criteria, as described in Tier 1 Section 2.7.6.1 and Section 2.7.6.2, are met in the as built plant.

The staff's evaluation of Tier 1 Section 2.7.6.1 determined that the applicant had not provided sufficient design details to develop proper ITAAC to verify the construction and operation of the NFP components that are important to safety. In RAI 132-1538, Question 9.1.2-15, the staff requested the applicant to include in Tier 1 Section 2.7.6.1, a more detailed description of the components and functions that ITAAC 2.7.6.1-2 will be verifying. In its RAI response dated January 29, 2009, the applicant proposed to revise the DCD Tier 1 existing ITAAC Item 1 in Table 2.7.6.1-1 to assure that the NFP features that are important to safety are verified.

In addition, in Revision 3 of the DCD, the applicant further modified Tier 1 Section 2.7.6.1 and Section 2.7.6.2. The staff evaluated the new Section 2.7.6.1 ITAAC and determined the modified ITAAC, is considered to be acceptable because it requires the verification of the NFP features that are important to safety. Therefore, the staff considers its concerns as described in RAI 132-1538, Question 9.1.2-15, to be resolved.

The staff's evaluation of Tier 1 Section 2.7.6.2, determined that the applicant had not provided sufficient design details to develop proper ITAAC to verify the construction and operation of the SFP components that are important to safety. In RAI 132-1538, Question 9.1.2-16, the staff requested the applicant to include in Tier 1 Section 2.7.6.2, a more detailed description of the components and functions that ITAAC 2.7.6.2-2 will be verifying. In its RAI response dated January 29, 2009, the applicant proposed to change DCD Tier 1 to include verification that the SFP features important to safety are properly constructed. The RAI response stated that Tier 1 Table 2.7.6.2-1, entitled "Spent Fuel Storage Inspections, Tests, Analyses, and Acceptance Criteria," would be expanded to verify demonstration of subcriticality.

In addition, in Revision 3 of the DCD, the applicant further modified Tier 1 Section 2.7.6.1 and Section 2.7.6.2. The staff evaluated the new Section 2.7.6.2 ITAAC and determined the modified ITAAC to be acceptable because they require the verification of the NFP and the SFP features that are important to safety. Therefore, the staff considers its concerns as described in RAI 132-1538, Question 9.1.2-16, to be resolved.

Section 9.1.1 of this SE addresses the staff's evaluation of the SFP criticality evaluation.

The NRC staff finds that the application is compliant with 10 CFR 52.47(b)(1).

Technical Specifications

Two TS limiting conditions of operation (LCO) are defined that apply to spent fuel storage. The first LCO involves maintaining an adequate water depth in the SFP to allow safe movement of spent fuel elements (TS 3.7.12). The frequency of Surveillance Requirement (SR) 3.7.12.1 is stated to be seven days. This surveillance interval is adequate for normal conditions, but may not be sufficient for all plant operations. In RAI 132-1538, Question 9.1.2-17, the staff requested the applicant to justify why the frequency of SR 3.7.12.1 should not be modified to "every 7 days and at the start of any spent fuel movement campaign." In its RAI response dated January 29, 2009, the applicant proposed to change the wording of SR 3.7.12.1, as described in RAI 132-1538, Question 9.1.2-17. The staff finds this change to be acceptable because it is more conservative than the original SR interval. The staff reviewed Revision 2 of the DCD and confirmed that it contains the DCD changes described in the applicant's response to RAI 132-1538, Question 9.1.2-17. Therefore, the staff considers its concerns as described in RAI 132-1538, Question 9.1.2-17, to be resolved.

Section 16, "Technical Specifications," of this SE further addresses the staff's evaluation of the TS for SFP including LCOs and surveillance frequency control program for SFP cooling and purification system (SFPCS).

Initial Testing

Section 14.2.12.1.85, "Spent Fuel Pit Cooling and Purification System Preoperational Test," provides guidelines for testing the SFP cooling system and purification systems. The staff finds that this test will also provide testing of the SFP itself. The procedure states that the pool will be partially filled up to the level of water necessary to perform its design basis functions; that water level is maintained and demonstrated by the instrumentation described in Section 9.1.3.1.

Section 9.1.3 of this SE addresses the staff's evaluation of DCD Tier 2 Section 14.2.12.1.85, for testing the SFPCS.

9.1.2.5 Combined License Information Items

The DCD Tier 2, Revision 3, Section 9.1.6 contains one COL information item pertaining to the new and spent fuel storage system. The acceptability of the COL item is evaluated above in this SER section. The staff concluded that no additional COL information items were needed.

Table 9.1.2-1
US-APWR Combined License Information Items

Action Item No.	COL Item No.	Description	Section
	9.1(9)	The COL Applicant is to create a procedure that will instruct the operator to perform formal inspection of the integrity of the spent fuel racks.	9.1.2

9.1.2.6 Conclusions

As described above, the staff concludes that the US-APWR SFP and SFP designs are in compliance with applicable General Design Criteria (GDC) of 10 CFR 50, Appendix A, *Code of Federal Regulations*, and the recommendations in SRP Section 9.1.2. The review of the DCD indicates that the new and spent fuel storage designs are acceptable and meet regulatory requirements. The ITAAC, TS, and COL applicant requirements were reviewed to ensure that site-specific information not provided in the DCD is identified and addressed with respect to new and spent fuel storage.

The choice of materials for the SFP liner and rack should minimize the problems with corrosion or deterioration in performance. If the water chemistry in the SFP is maintained as specified in the DCD, the materials of the construction are sufficiently compatible with SFP water to satisfy the requirements of RG 1.13, ANS-57.2, and the EPRI Guidelines. Hence, the staff concludes, based on the information supplied by the applicant, that the requirements of GDC 14, GDC 61, and GDC 63 have been met.

9.1.2.7 References

1. *"Spent Fuel Storage Facility Design Basis*," RG 1.13, Revision 2, U.S. Nuclear Regulatory Commission (issued March 2007).
2. *"American National Standard, Design Requirements for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Plants*," ANSI/ANS-57.2-1983, American Nuclear Society (issued October 1983).
3. *"Pressurized Water Reactor Primary Water Chemistry Guidelines*," Volume 1, Revision 6, Electric Power Research Institute (issued December 2007).
4. Letter from Yoshiki Ogata, MHI, to the NRC dated March 30, 2009; Docket No. 52-021 MHI Ref: UAP-HF-09128; Subject: MHI's Response to US-APWR DCD RAI No. 248-2178 Revision 1 (ADAMS Accession No. ML090910646).
5. Letter from Yoshiki Ogata, MHI, to the NRC dated July 14, 2009; Docket No. 52-021 MHI Ref: UAP-HF-09374; Subject: MHI's Response to US-APWR DCD RAI No. 389-2919 Revision 1 (ADAMS Accession No. ML091980037).
6. Letter from Yoshiki Ogata to the NRC dated March 30, 2009; Docket No. 52-021; MHI Ref: UAP-HF-09125; Subject: MHI's Responses to US-APWR DCD RAI No. 247-2179 Revision 1; (ADAMS Accession No. ML090910642).

9.1.3 Spent Fuel Pit Cooling and Purification System (Related to RG 1.206, Section C.III.1, Chapter 9, C.I.9.1.3, "Spent Fuel Pool Cooling and Cleanup System")

9.1.3.1 Introduction

The US-APWR design includes a SFP for the wet storage of spent fuel assemblies. The safety function to be performed by the spent fuel cooling system (in conjunction with the SFP itself) is to assure that the spent fuel assemblies are cooled and remain covered with water during all storage conditions. Other functions performed by the system, but not related to safety, include water cleanup for the SFP, refueling canal, refueling water storage tank, and other equipment storage pools.

9.1.3.2 Summary of Application

DCD Tier 1: The DCD Tier 1 information associated with this section is found in Tier 1, Section 2.7.6.3 of the US-APWR DCD, Revision 3.

DCD Tier 2: The applicant has provided a Tier 2 description of SFPCS in Section 9.1.3 of the US-APWR DCD, Revision 3, summarized here in part, as follows:

> The SFPCS consists of two 100 percent cooling capacity trains. Each train includes one SFP pump, one SFP (HX), one SFP filter, and one SFP demineralizer. In addition, each train of equipment has its own suction and discharge headers and includes the piping, valves, and instrumentation necessary for system operation.

Each SFPCS train contains a cooling portion for cooling the SFP and a purification portion for purification of the BA water in the SFP, RWSP, refueling water storage auxiliary tank, and the refueling cavity. Cooling is performed for the SFP water by circulating the SFP water by the SFP pump and removing decay heat through the SFP HX. Purification is performed by bypassing a portion of the cooling water through the demineralizer and filter, and removing solid materials and dissolved impurities. The cooling and purification flow paths are shown in DCD Figure 9.1.3-1 , entitled “Schematic of Spent Fuel Pit Purification and Cooling System (Cooling Portion),” and DCD Figure 9.1.3-2, entitled “Schematic of Spent Fuel Pit Purification and Cooling System (Purification Portion),” respectively.

The RWSP is the primary water source for the SFP through a safety-related BA water makeup line. As a backup, another makeup line is provided from the emergency feedwater pit (EFP). Makeup water could also be provided from the demineralized water system (DWS).

ITAAC: The ITAAC associated with Tier 2, Section 9.1.3 are given in Tier 1, Section 2.7.6.3.2.

TS: There are no TS for this area of review.

9.1.3.3 Regulatory Basis

The relevant requirements of the Commission’s regulations for this area of review, and the associated acceptance criteria, are given in Section 9.1.3 of NUREG-0800, the SRP, and are summarized below. Review interfaces with other SRP sections can be found in Section 9.1.3.I of NUREG-0800.

1. GDC 2 of Appendix A to 10 CFR Part 50, as related to structures housing the system and the system itself being capable of withstanding the effect of natural phenomena like earthquakes, tornadoes, and hurricanes.

2. GDC 4, with respect to the capability of the system and the structure housing the system to withstand the effects of external missiles.

3. GDC 5, as related to shared SSCs important to safety being capable of performing required safety functions.

4. GDC 14, “Reactor Coolant Pressure Boundary,” which relates to maintaining the RCPB by controlling RCS purity. (Note: although not cited in SRP 9.1.3, GDC 14 is relevant because the SFP water enters the RCS during refueling operations.)

5. GDC 61, as related to the system design for fuel storage and handling of radioactive materials, including the capability for periodic testing; provisions for containment, provisions for decay heat removal; capability to prevent reduction in fuel storage coolant inventory under accident conditions; and capability and capacity to remove corrosion products, radioactive materials and impurities from the pool water and reduce occupational exposures to radiation.

6. GDC 63, as it relates to monitoring systems provided to detect conditions that could result in the loss of decay heat removal capability, to detect excessive radiation levels, and to initiate appropriate safety actions.

7. 10 CFR 20.1101(b), as it relates to radiation doses being kept ALARA.

8. 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, the facility has been constructed and will operate in conformity with the COL, the provisions of the Atomic Energy Act of 1954, and the NRC's regulations.

Acceptance criteria adequate to meet the above requirements are:

1. Acceptance for meeting the relevant aspect of GDC 2 is based on conformance to Positions C.1, C.2, C.6, and C.8 of RG 1.13, Position C.1 of RG 1.29 for safety-related, and Position C.2 of RG 1.29 for nonsafety-related portions of the system. This criterion does not apply to the cleanup portion of the system and need not apply to the cooling system if the pool makeup water system and its source meet the criterion, the fuel pool building and its ventilation and filtration system meet the criterion, and the ventilation and filtration system meets the guidelines of RG 1.52. The cooling and makeup system should be designed to Quality Group C requirements in accordance with RG 1.26. However, when the cooling system is not designated Seismic Category I, it need not meet the requirements of Section IX of the American Society of Mechanical Engineers (ASME) Code for in-service inspection of nuclear plant components.

2. Acceptance for meeting GDC 4 is based on meeting Position C.2 of RG 1.13. The criterion does not apply to the cleanup system and need not apply to the cooling water system if the makeup system, its source, the building, and its ventilation and filtration system are tornado protected, and the ventilation and filtration system meets the guidelines of RG 1.52.

3. Acceptance for meeting GDC 14 is based on the SFP chemistry following the recommendations of the EPRI "*PWR Primary Water Chemistry Guidelines*." Although the staff does not formally review or issue a SE of the various EPRI water chemistry guidelines (including the "*PWR Primary Water Chemistry Guidelines"*), the guidelines are recognized as representing industry best practices in water chemistry control. Extensive experience in operating reactors has demonstrated that following the EPRI Guidelines minimizes the occurrence of corrosion related failures. Further, the EPRI Guidelines are periodically revised to reflect evolving knowledge with respect to best practices in chemistry control. Therefore, the staff accepts the use of the EPRI "*PWR Primary Water Chemistry Guidelines,"* as a basis for a recommended primary water chemistry program for a standard reactor design.

4. In meeting the requirements of 10 CFR 20.1101(b); RG 8.8, Positions C.2.f(2) and C.2.f(3) can be used as a basis for acceptance.

9.1.3.4 Technical Evaluation

The staff reviewed the US-APWR DCD, Revision 3, Tier 2 Section 9.1.3, "Spent Fuel Pit Cooling and Purification System," in accordance with the guidance provided by NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," Section 9.1.3, "Spent Fuel Pool Cooling and Cleanup System," Revision 2 dated March 2007. The SFPCS removes decay heat generated by irradiated fuel stored in the pool and also removes impurities and fission products from the pool water.

As described in DCD Tier 2 Section 9.1.3, the SFPCS consists of two independent 100 percent cooling capacity trains of equipment. Each train consists of one SFP pump, one SFP HX, one SFP demineralizer, one SFP filter, valves, piping and instrumentation and controls necessary for system operation. The two trains of equipment have their own suction and discharge headers. Either train can perform any of the functions required of the SFPCS independently of the other train. One train is continuously cooling and purifying the SFP, while the other train is available for water transfers or refueling water storage purification or is aligned as a backup to the operating train of equipment.

GDC 2

SRP Section 9.1.3 describes staff positions related to the design of the SFP cooling and cleanup system. It cites RG 1.13 to describe the design basis, RG 1.26 to describe quality group classifications, and RG 1.29 to describe seismic design classifications. These positions describe the design bases needed to mitigate expected natural phenomena when combined with the appropriate effects of normal and accident conditions.

In DCD, Revision 3, Tier 2, Section 9.1.3, the applicant states that the SFPCS, which is the cooling portion of the SFPCPS, is safety-related, powered from class 1E power sources, and designed as a Seismic Category I system. The purification portion of the SFPCS, i.e., piping, demineralizers, and filters, is non-safety related. The SFPCPS is located in the RB. In Tier 2 DCD, Section 3.2, "Classification of Structures, Systems and Components," provides the SSCs based on safety importance and other considerations. Table 3.2-2, "Classification of Mechanical and Fluid Systems, Components, and Equipment," provides the component safety classification, seismic classification, quality group classification, comment commercial codes and locations for the SSCs. The staff finds that the safety classification, quality group, seismic category and location for SFPCS are properly designated. All safety-related portions of the SFPCS are located inside seismic Category I, tornado-, missile-, and flood-protected buildings.

In DCD Revision 3, Section 9.1.3.2.1.7, "Valves," states that manual valves are used to isolate the safety-related cooling portion of the SFPCPS from the nonsafety-related purifications portion, in case any leaks or failures occur on the non-safety portion. The DCD does not address how these valves would provide timely isolation of the safety-related portion of the SFPCPS from the non-safety related portion, upon a seismic event or an internally generated missile event. In RAI 735-5723, Question 9.1.3-7, the staff requested the applicant to provide additional information in Tier 2, Section 9.1.3 to address how failures of nonsafety-related portions of the SFPCS would not adversely affect the safety-related portion of the SFPCS.

In its RAI response dated June 22, 2011, the applicant stated that the SFP is designed with features that prevent the draining of the coolant below the minimum water level. The applicant's response also stated that under maximum heat load conditions, the SFP has sufficient water inventory that it would take 2.5 hours before the water would start boiling. The applicant stated that this provides the operator with sufficient time to identify and isolate the break in the SFPCS.

The staff evaluated the applicant's RAI response and found that this response does not address or justify why it is acceptable to allow non safety-related SSCs to challenge the operability of safety related SSEs. During a phone conference with the applicant on August 7, 2011, the staff expressed its evaluation of the applicant's response. The applicant stated it is going to revise the response to RAI 9.1.3-7 in order to justify how the design of the SFPCS meets the requirements of GDC 2 and GDC 4. **The staff is tracking the resolution of RAI 735-5723, Question 9.1.3-7 as Open Item 9.1.3-7.**

Based on its review as discussed in Sections 3.4.1, 3.5.1.1, 3.5.1.2, 3.5.1.4 and 3.5.2 of this report, as described below, the staff finds that (pending satisfactory resolution of **Open Item 9.1.3-7**) the SFPCS meets the relevant requirements of GDC 2 as it pertains to Position C.2 of RG 1.29. The SFPCS also meets the relevant requirements of GDC 2 as it pertains to Position C.1 of RG 1.29.

Section 3.4.1 of this SE addresses the staff's evaluation of flood protection provided for SSCs important to safety.

Section 3.5.1.1 of this SE addresses the staff's evaluation of protection provided for SSCs important to safety from internally generated missiles outside containment.

Section 3.5.1.4 of this SE addresses the staff's evaluation of protection provided for SSCs important to safety from missiles generated by natural phenomena.

Section 3.5.2 of this SE addresses the staff's evaluation of protection provided for SSCs important to safety from externally generated missiles.

GDC 4

The staff reviewed the Component Cooling Water System (CCWS) to determine if the design meets the relevant requirements of GDC 4. DCD Tier 2, Section 9.1.3.3.5, "Natural Phenomena and Missiles," states that the SFPCS provides protection of essential components against natural phenomena and internal and external missiles. Additionally, the SFPCS is located inside the RB, which is a Seismic Category 1 structure that provides additional protection against external missiles.

Based on this, the staff finds that the SFPCS is protected against the effects of, and is compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, as recommended in SRP 9.1.3. Therefore, the staff concluded that the SFPCS meets the requirements of GDC 4.

GDC 5

Compliance with GDC 5 requires that SSCs important to safety not be shared among nuclear power units unless it can be shown that such sharing will not impair their ability to perform their safety functions.

Since the US-APWR design is a single-unit design, the requirements of GDC 5 are not applicable. The COL applicant that proposes a multiple unit site must comply with the requirements of GDC 5. Therefore, the staff finds that the design of the SFPCS satisfies the requirements of GDC 5, since the SSCs important to safety are not shared between units.

GDC 61

Compliance with GDC 61 requires that the fuel storage system be designed to ensure adequate safety under normal and postulated accident conditions. The system should be designed with: the capability to permit appropriate periodic inspection and testing of components important to safety; suitable shielding for radiation protection; appropriate containment, confinement and filtering capability; residual heat removal that reflects the importance to safety of decay heat and other residual heat removal; and the capability to prevent a significant reduction in fuel storage coolant inventory under accident conditions.

SRP Section 9.1.3.III.1.D states that the cooling system should be designed such that it retains at least half of its full heat removal capacity assuming a single active failure. This lower capacity provides reasonable assurance that the pool temperature will remain within design bounds for the structure during full core discharges to the SFP when the forced-circulation cooling system is in operation, and ensures that sufficient heat removal capacity will remain available when an active component is unavailable due to a single failure or maintenance.

DCD Tier 2 Section 9.1.3.1, “Design Basis,” states that the SFPCS is designed to maintain the water temperature below 48.9°C (120°F) with a newly off loaded half core and a fully loaded SFP, with a single active failure preventing the use of one cooling train. With the additional capacity of the residual heat removal system, an entire newly off loaded core can be handled without the water temperature rising above 60°C (140°F). This also accounts for the possibility of a single active failure. Therefore, the SFPCS design meets the recommendations of SRP Section 9.1.3.III.1.D

Each non-safety related redundant purification loop of the SFPCS can be connected to the refueling water system to process refueling water when the purification loop is not used by the SFPCS. The purification loops can be isolated from the safety related cooling porting of the system, if this is needed as specified by the SRP. The purification loop can also be aligned to purify refueling cavity water during refueling operations and prior to discharge. All purification filters are disposed via the radwaste system as described in DCD Tier 2 Chapter 11, “Radioactive Waste Management.”

SRP 9.1.3.III.1.E states that the SFP and cooling systems should be designed so that in the event of failure of inlets, outlets, piping, or drains, the pool level will not be inadvertently drained below a point approximately 3 meters (10 feet) above the top of the active fuel. In DCD Tier 2 Section 9.1.3, the applicant stated that both trains are designed to process SFP water. Each pump takes suction from separate headers and discharges approximately 7 percent of the flow to the purification branch and the rest to its respective HX. Each purification branch is routed to a SFP demineralizer. The outlet of the demineralizer is routed to an SFP filter. The outlet of the filter then returns to the SFP. The SFP cooling system suction header connects to the SFP at an elevation 1.2 meters (4 ft) below the normal water level of the pool, which is above the level that will provide 3 meters (10 feet) of water coverage above the top of the active fuel. The return line contains a siphon breaker located near the surface of the pool. This arrangement prevents the SFP from inadvertently being drained below a level that would prevent the water in the SFP from performing its safety functions of shielding and cooling of the spent fuel. The staff finds that these design features are consistent with the guidance of SRP 9.1.3.III.1.E.

SRP 9.1.3.III.1.F discusses the appropriate design of the makeup system. The SRP recommends that a seismic Category I, Quality Group C makeup system and an appropriate backup method to add coolant to the SFP should be provided. If the forced-circulation cooling system is designed to seismic Category I, Quality Group C standards, the backup system need not be a permanently installed system, or Category I, but should take water from a seismic Category I source. The SRP also provides guidelines to determine the minimum makeup capacity required.

In DCD Tier 2 Section 9.1.3.2, "System Description," the applicant states that in the unlikely event that the SFPCS fails, the applicant has provided a safety related, seismic Category I line to provide borated makeup water from the seismic Category I, RWSP at a rate of 200 gpm (757 L/min). The DCD also states that additional makeup to the SFP is provided from the EFP at a rate of 100 gpm (378 L/min). The EFP is a seismic category I structure. The line from the EFP to the SFP is also provided with a backup line that is non-seismic. The SFP can also obtain makeup water from the DWS at a rate of 150 gpm (567 L/min). The demineralized water storage tank and the makeup line to the SFP are non-seismic.

All makeup lines are permanent, and thus will not require significant amounts of time to initiate manual makeup activities. Boron may be added to the SFP from the chemical and volume control system (CVCS). A gate is used to separate the SFP water from the water in the transfer canal. The gate enables drainage of the transfer canal to permit maintenance of the fuel transfer equipment.

In DCD Tier 2 Section 9.1.3, the applicant has not provided the basis of the boil-off rate calculations. The application does not specify the worst boil-off rates for the different offloading scenarios (normal and full core offloads), the minimum required makeup for the different offloading scenarios, and the flow rate capabilities of the various make up systems are mentioned above. In RAI 131-1609, Question 9.1.3-2, the staff requested the applicant to update DCD Tier 2 to include this missing information and the basis, assumptions, and results of the SFPCS thermal analysis. In a letter dated January 29, 2009, (MHI Ref: UAP-HF-09026) the applicant responded to this RAI providing additional design information and proposed changes to the DCD that added design details of the SFPCS. The response stated that it is very unlikely that boiling would ever occur in the spent fuel storage facility. If a series of events does occur that results in boiling of the SFP water inventory, a number of makeup water sources are identified that would prevent fuel damage. The applicant also provided a thermal analysis report (Thermal-Hydraulic Analysis for US-APWR Spent Fuel Racks, issued June 2009, Technical Report MUAP-09014P) that provided the thermal calculations to justify its design. The report states that, assuming a maximum heat load and minimum water level, it would take approximately 2.7 hours for the SFP water to start boiling. The maximum boiloff rate for any of the boil-off scenarios evaluated was 121 gpm (458 L/m).

The staff evaluated the applicant's response and confirmed that the SFPCS has been designed with makeup water sources of sufficient capacity to offset the boiloff rate and prevent stored fuel damage. The staff also verified that Revision 3 of the DCD contains the DCD changes proposed in the RAI response, and thus RAI 131-1609, Question 9.1.3-2 is to be considered closed. Therefore, the staff finds that the SFPCS design meets the guidance of SRP Section 9.1.3.III.1.F

SRP 9.1.3.III.1.G states that design provisions have been made that permit appropriate inservice inspection and functional testing of system components important to safety.

In DCD Tier 2 Section 9.1.3.4, “Inspection and Testing Requirements,” the applicant states that the inservice inspection of pumps, valves, and piping is performed in accordance with the requirements of ASME Section XI. This is discussed in DCD Tier 2 Section 6.6, “Inservice Inspection of Class 2 and 3 Components.” Inservice testing of active pumps and valves is performed to assure operational readiness as described in DCD Tier 2 Section 3.9.6, “Functional Design, Qualification, and Inservice Testing Programs for Pumps, Valves, and Dynamic Restraints.” Sampling of the fuel pit water for gross activity and particulate matter concentration is conducted periodically. These design features are consistent with the guidance of SRP Section 9.1.3.III.1.G.

Based on the above discussion, the staff finds that the SFPCS design has met the guidance of SRP Section 9.1.3, and that, therefore, the system design meets the requirements of GDC 61.

GDC 63

Compliance with GDC 63 requires that appropriate systems be provided in the fuel storage area to detect conditions that may result in the loss of residual heat removal (RHR) capability or excessive radiation levels, and initiate appropriate safety actions.

The US-APWR design provides instrumentation to measure temperature, pressure, flow, radioactivity and water level in the SFP. The temperature, radiation and water levels are equipped with alarms to warn the operators of dangerous conditions. However, the applicant has not proposed to include a low flow rate alarm. This is not consistent with the guidance of SRP 9.1.3 Section IV.5. In RAI 131-1609, Question 9.1.3-3, the staff requested the applicant to include, in the DCD, a justification for not having a low flow rate alarm. In its letter dated January 29, 2009, (MHI Ref: UAP-HF-09026) the applicant responded to this RAI stating that the low flow rates and loss of flow can be detected by other factors that are monitored and alarmed, such as SFP temperature and level. Regardless, the applicant proposed to add low flow alarms to the spent fuel cooling systems and proposed additions to the DCD that describe this added feature. Revision 3 of the DCD submission contains the revisions described in the RAI response, and thus RAI 131-1609, Question 9.1.3-3 is considered to be closed.

DCD Tier 2 Section 8.3.1.1.3.6, discusses the load shedding and sequencing circuits for the Class 1E 6.9kV buses. This DCD section states that, should a loss of coolant accident (LOCA) occur, concurrently with a loss of offsite power (LOOP), the emergency core cooling system (ECCS) actuation signal initiates the ECCS load sequence. Loads that are not required by the ECCS (except the MCR loads) are shed. Since the SFPCS is not needed to support emergency core cooling, it would be shutdown in this scenario.

DCD Tier 2 Section 9.1.3, “Spent Fuel Pit Cooling and Purification System,” describes the operation of the safety related SFPCS. It appears that the system description provided in Section 9.1.3 is not consistent with the scenario discussed in DCD Tier 2 Section 8.3.1.1.3.6. In RAI 756-5753, Question 9.1.3-8 and RAI 763-5814, Question 9.1.3-9, the staff requested the applicant to revise DCD Tier 2 Section 9.1.3, to discuss any automatic actuation signal that would shutdown the SFPCS, to justify why there is no automatic loading of the SFPCS, to discuss how the SFP conditions (i.e. level, temperature, etc.) are monitored, what instrumentation is credited to monitor these conditions, and to discuss any operator actions needed to re-establish the SFPCS and the time frame in which these actions are required to take place.

In letters dated August 10, 2011, and August 23, 2011, the applicant responded to RAI 756-5753, Question 9.1.3-8 and RAI 763-5814, Question 9.1.3-9. The applicant's response states that under LOOP conditions, the SFPCS pumps will shutdown due to an undervoltage trip signal. These pumps are not automatically loaded by the sequencer. The operator will monitor conditions in the pool and re-start the cooling system prior to the pool reaching 93.3ºC (200ºF). With maximum SFP heatload, the operator has over 2.5 hours to initiate the cooling system from the control room before boiling s reached. The applicant response added the instruments used by the operator to monitor the SFP conditions (temperature, flow rate to the HX and level instruments) do not meet the requirements to be classified as safety related components. However, since these instruments are of importance to identify and monitor SFP conditions, the applicant proposed to upgrade these instruments and classify them as safety-related. The applicant's response also proposed to update the DCD to better describe this scenario. The proposed DCD changes include:

- Updating Tier 1 Table 2.7.6.3-1, "Spent Fuel Pit Cooling and Purification System Equipment Characteristics," and Table 2.7.6.3-3, "Spent Fuel Pit Cooling and Purification System Equipment Alarms, Displays and Control Functions," to verify proper installation of the safety related instruments used to monitor SFP conditions (SFP water level, Spent Fuel Storage – Loss of Instrument Air (SFS-LIA-01 0, 020), SFP temperature monitor SFS-TIA-01 0, 020, and SFP pump discharge flow monitor SFS-FIA-032, 042),

- Updating Tier 2, Table 3d-2, "US-APWR Environmental Qualification Equipment List," to add the instruments mentioned above, and

- Revising Tier 2 Section 9.1.3 to discuss this mode of operation.

The staff evaluated the applicant's response and determined that the SFP initial conditions (water level, temperature, and heatload) at the time of a LOOP signal will ensure that no immediate action is required to maintain the SFP in a safe condition, therefore, the staff agrees that the SFPCS does not need to be automatically loaded into the sequencer. The use of safety-related instruments to monitor conditions in the SFP provide confidence that these instruments can be credited to be operational in the scenario discussed above. The staff also reviewed the description of the operator actions needed to re-start the SFPCS and concluded that the operator will have sufficient time to complete the required actions in order to protect the stored fuel. Therefore, the staff finds the RAI response to be acceptable and considers RAI 756-5753, Question 9.1.3-8 and RAI 763-5814, Question 9.1.3-9 to be considered closed. The inclusion of the proposed changes described in the response to RAI 9.1.3-8 is being tracked as **Confirmatory Item 9.1.3-8**. **[CI 9.1.3-8].**

Based on the staff evaluation discussed above, the staff concludes that the SFPCS complies with the requirements of GDC 63.

Chemistry and Materials Aspects (GDC 14, GDC 61)

The purpose of this review is to assess the capability of the SFPCS in maintaining water purity in the SFP and RWSP. This is required by GDC 61, to reduce corrosion in the spent fuel assemblies and various structures in the SFP. SRP 9.1.2 mentions that the specifications in ANSI/ANS-57.2 (Reference 2) fulfill the requirements of GDC 61. The SFP water can also enter the RCS during refueling and the SFPCS may serve as an alternate water source to the chemical and volume control system; hence, maintaining purity of SFP water is also required by

GDC 14, to ensure the purity of the RCS water. The EPRI Guidelines are mentioned in SRP 9.3.4 as a means of satisfying this requirement of GDC 14.

The SFPCS consists of two independent processing streams, which draw water from the SFP, RWSP, and associated smaller volumes. Each stream passes through a strainer and HX before returning to its source volume. A smaller stream bypasses the HX and is routed through a purification loop, passing through a demineralizer and filter. This purification stream is designed to process 265 gal/min (0.0167 m^3/s), which implies that all water (a total of 3816 m^3, of which 1514 m^3 is from the SFP and 2302 m^3 from the RWSP) is processed by a single stream in under 64 hours. Since there are two independent streams, the entire system could be processed in about 32 hours, which is well within the limit of 72 hours required by ANSI/ANS-57.2 (Section 6.3.2.10).

Water in the SFP and RWSP is specified to contain a minimum of 4000 ppm BA. Makeup water is supplied to the SFP and RWSP from a borated water tank or from a demineralized water storage tank. Thus, water to replace evaporation or leakage can maintain the required BA concentration.

As mentioned above, the SFPCS consists of HXs, filters, strainers, demineralizers, and piping. All portions of the system that contact borated water are constructed of stainless steel. This is consistent with the requirements for SFP liner and storage racks specified in ANSI/ANS-57.2 (Section 6.1.2.10 and Section 6.4.2.17), and with the recommendation in the EPRI Guidelines (p. B-11).

Water chemistry in the SFP is checked at local points and in the inlet and outlet lines for each demineralizer. In its response to RAI 360-2767, Question No. 9.1.3-6, (Reference 3), dated May 28, 2009, the applicant provided an updated table describing the frequency and the allowed limits for various solutes during routine sampling. This information is fully consistent with the EPRI Guidelines, and in some cases is more stringent; the applicant committed to incorporate the table in a revision of the DCD. Therefore, the staff finds the response to RAI 360-2767, Question No. 9.1.3-6, to be acceptable. The staff verified that the revised table is included in Revision 2 of the DCD. In anticipation of refueling operations, the EPRI Guidelines suggest monitoring of additional impurities (Section B.6.2) may be necessary to prepare the SFP water for entry into the RCS. The applicant mentions in its response to RAI 201-2199, Question No. 9.1.3-5 (Reference 4), dated March 26, 2009, that confirmatory evaluations of SFP water chemistry would be carried out prior to refueling. While the applicant does not specify exactly what parameters would be measured, it does state that the recommendations of the EPRI Guidelines would be met; thus, the staff finds the response to RAI 201-2099, Question No. 9.1.3-5, to be acceptable.

Maintenance of optical clarity of the SFP water (ANSI/ANS-57.2, Section 6.3.2.9.1) is also required. The EPRI Guidelines mention a skimmer as part of the system that could be important in maintaining optical clarity. In its response to RAI 201-2199, Question 09.01.03-04, dated March 26, 2009, the applicant indicated that it does not intend to provide a skimmer (Reference 4). It asserts that where skimmers have been used they were often unnecessary in maintaining water purity, and that the Japanese experience in several plants without skimmers indicates that SFP water can be cleaned adequately. Furthermore, the surface area drawn through each skimmer is limited and varying water levels limit the effectiveness of skimmers generally. A simple calculation using the data in DCD Figure 9.1.3-2, entitled “Schematic of Spent Fuel Pit Purification and Cooling System (Cooling Portion),” and Figure 9.1.3-1 “Schematic of Spent Fuel Pit Purification and Cooling System (Purification Portion),” suggests that the suction flow velocity from one train of the SFPCS (3865 gpm (0.244 m^3/s) through a 16-inch (0.406 m) pipe is about 6.2 ft/s (1.89 m/s). The design features of the SFPCS indicate that the inlet is about four feet below the normal water surface, and that the discharge flow is within a foot of the surface. These features suggest that considerable surface agitation will result and that surface films or debris will be drawn into the SFPCS fairly readily. Thus, based on the applicant's discussion of operating experience and the staff's calculation, the staff agrees with the applicant's assertion that the SFPCS can adequately clean the SFP water without surface skimmers, and finds the response to RAI 201-2099, Question 9.1.3-4, to be acceptable.

ALARA

Section 12.0 of this report addresses the staff's evaluation of the operational radiation protection program and radiation protection design features provided to assure that OREs are ALARA as required in 10 CFR 20.1101(b).

Inspections, Tests, Analyses, and Acceptance Criteria

DCD Tier 1, Section 2.7.6.3, "Spent Fuel Pit Cooling and Purification System," provides a number of ITAAC items for the SFPCS. These include:

- Inspection of the as built plant to assure equipment conforms to the design.
- Inspection of the as built plant to assure that the applicable ASME codes were followed.
- Inspection of the as built plant to assure the integrity of the welds.
- Hydrostatic tests to assure that the design pressure levels can be achieved.
- Inspections to assure the equipment is located within seismic qualified buildings.
- Inspections, tests and/or analysis to confirm that the seismic goals are met.
- Electrical inspections and tests to assure that independent trains are on separate divisions.
- Inspections to assure separation of cables for each division.
- Tests for adequate flow rates delivered by the SFPCS pumps.
- Inspections to assure that displays in the MCR reflect system conditions.

These ITAAC commit to verify that the SFPCS are designed and performed as described in the US-APWR DCD Tier 2, Revision 3. Therefore, the staff concludes that **(pending resolution of CI-9.1.3-8),** with regard to the SFPCS design the applicant has complied with the requirements of 10 CFR 52.47(b)(1).

Technical Specifications

The TS include LCOs that apply to SFPCS. The first LCO (TS 3.7.12) involves maintaining an adequate water depth in the SFP to allow safe movement of spent fuel elements. The frequency of SR 3.7.12.1 is stated to be seven days or in accordance with the surveillance frequency control program. The second LCO (TS 3.7.13) involves maintaining adequate boron concentration in the SFP. The frequency of SR 3.7.13.1 is stated to be seven days or in accordance with the surveillance frequency control program.

The staff evaluated TS 3.7.12 and TS 3.7.13 and found them to be consistent with the standard TS. Section 16, "Technical Specifications," of this SE and addresses a more detailed evaluation of the TS, including SFPCS LCOs and surveillance frequency control program.

Initial Plant Test Program

Section 14.2.12.1.85, "Spent Fuel Pit Cooling and Purification System Preoperational Test," in Tier 2 of the DCD provides a list of preoperational tests to be performed on the SFPCS. The goals of these tests include:

- Demonstrate operability and control of the system.
- Demonstrate pumping capacity during various operational modes.
- Demonstrate the siphon breaker performance to prevent pool drainage.
- Demonstrate operation of the SFP low level alarm.
- Demonstrate pumping of makeup water from the RWSP.
- Demonstrate the water tight gates separating the SFP from the refueling canal.

The staff's review of the proposed test programs is discussed in Section 14.2 of this SE.

9.1.3.5 Combined License Information Items

There are none identified in the US-APWR DCD for Section 9.1.3. The staff found this appropriate.

9.1.3.6 Conclusions

The staff's review of the SFPCS design also included the SFPCS ITAAC, pre-operational testing and TS and found that these sections provided reasonable assurance that the SFPCS will be inspected, tested and operated in accordance with the SFPCS design basis.

Based on the review summarized above, the staff concluded that **(pending resolution of CI 9.1.3-8)** the SFPCS design is consistent with the guidance of NUREG-0800 SRP 9.1.3 and that the information provided adequately demonstrates that the requirements of 10 CFR Part 50, Appendix A, GDC 2, GDC 4, GDC 5, GDC 61, GDC63, and 10 CFR 20.1101(b) have been met. In addition, the proposed ITAAC requirements are sufficient to demonstrate compliance with the certified design and therefore the requirements of 10 CFR 52.47(b)(1) have also been met.

Chemistry and Materials Aspects

The SFPCS has demonstrated sufficient capability to maintain purity in the SFP, RWSP, and other associated volumes. If the water chemistry in these volumes is maintained as specified in the DCD, then the requirements of ANS-57.2 and the EPRI Guidelines will be satisfied. The staff therefore concludes, based on the information supplied by the applicant, that the requirements of GDC 61 and GDC 14 have been met.

9.1.3.7 References

1. "*Pressurized Water Reactor Primary Water Chemistry Guidelines*," Volume 1, Revision 6, Electric Power Research Institute (issued December 2007).

2. "*American National Standard, Design Requirements for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Plants*," ANSI/ANS-57.2-1983, American Nuclear Society (issued October 1983).

3. Letter from Yoshiki Ogata, MHI, to the NRC dated May 28, 2009; Docket No. 52-021, MHI Ref: UAP-HF-09268; Subject: MHI's Response to US-APWR DCD RAI No. 360-2767 Revision 1 (ADAMS Accession No. ML091600147).

4. Letter from Yoshiki Ogata, MHI, to the NRC dated March 26, 2009; Docket No. 52-021, MHI Ref: UAP-HF-09126; Subject: MHI's Response to US-APWR DCD RAI No. 201-2199 Revision 1 (ADAMS Accession No. ML090920844).

9.1.4 Light Load Handling System (Related to Refueling)

9.1.4.1 Introduction

The light load handling system (LLHS) consists of all components and equipment for handling new fuel from the receiving station to loading spent fuel into the shipping cask. The objective of the system is to avoid criticality accidents, radioactivity releases from damage to irradiated fuel, and unacceptable personnel radiation exposures.

9.1.4.2 Summary of Application

DCD Tier 1: The DCD Tier 1 information associated with this section is found in Tier 1, Section 2.7.6.4 of the US-APWR DCD, Revision 3.

DCD Tier 2: The applicant has provided a Tier 2 description of the LLHS in Section 9.1.4 of the US-APWR DCD, summarized here, in part, as follows:

> The LLHS encompasses the equipment and structures involved in the handling of fuel, new, irradiated, and spent, for the US-APWR.
>
> The LLHS equipment involved includes the new fuel elevator, fuel handling machine, refueling machine, the suspension hoist of the spent fuel cask handling crane, fuel transfer system, and various fuel handling tools.
>
> The building structures associated with the LLHS are the refueling cavity located in the containment vessel, the SFP, the new fuel storage pit, the fuel inspection pit, the spent fuel cask pit, the spent fuel cask wash-down pit, the refueling canal, and the receiving area of the RB fuel handling area. Also included is the fuel transfer tube which penetrates from the refueling canal in the fuel pool handling area to the refueling cavity in the containment vessel enabling the transfer of fuel assemblies between the two areas.

ITAAC: The ITAAC associated with Tier 2, Section 9.1.4 are given in DCD Tier 1, Section 2.7.6.4.2.

TS: There are no TS for this area of review.

9.1.4.3 Regulatory Basis

The relevant requirements of the Commission's regulations for this area of review, and the associated acceptance criteria, are given in Section 9.1.4 of NUREG-0800, the SRP, and are summarized below. Review interfaces with other SRP sections can be found in Section 9.1.4.I of NUREG-0800.

1. GDC 2, "Design Basis for Protection Against Natural Phenomena," of Appendix A to 10 CFR Part 50, as it relates to the ability of the structures, equipment, and mechanisms to withstand the effects of earthquakes.

2. GDC 5, "Sharing of Structures, Systems, and Components," as it relates to safety-related structures not being shared among nuclear power units, unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions.

3. GDC 61, "Fuel Storage and Handling and Radioactivity Control," as it relates to the fuel storage and handling, radioactive waste, and other systems which may contain radioactivity shall be designed to assure adequate safety under normal and postulated accident conditions..

4. GDC 62, "Prevention of Criticality in Fuel Storage and Handling," states that criticality in the fuel storage and handling system shall be prevented by physical systems or processes, preferably by use of geometrically safe configurations.

5. 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, the facility has been constructed and will operate in conformity with the COL, the provisions of the Atomic Energy Act of 1954, and the NRC's regulations.

Acceptance criteria adequate to meet the above requirements are:

1. Acceptance for meeting the relevant aspects of GDC 2 is based on RG 1.29, Positions C.1 and C.2.

2. Acceptance for meeting the relevant aspects of GDC 61 is based in part on the guidelines of ANSI/ANS Standard 57.1-1992.

3. Acceptance for meeting the relevant aspects of GDC 62 is based in part on ANSI/ANS 57.1-1992.

9.1.4.4 Technical Evaluation

The staff reviewed Revision 3 of the US-APWR Standard DCD for the LLHS in accordance with NUREG-0800, "Standard Review Plan [SRP] for the Review of Safety Analysis Reports for Nuclear Power Plants," Section 9.1.4, "Light Load Handling System Related to Refueling," Revision 3, issued March 2007. Conformance with the acceptance criteria in Section II, of SRP Section 9.1.4, formed the basis for the evaluation of the LLHS with respect to the applicable regulations. The results and conclusions of the staff's review of the LLHS are discussed below. The evaluation addresses compliance with the SRP acceptance criteria listed in Section 9.1.4.3 of this SE.

A. GDC 2, "Design Basis for Protection Against Natural Phenomena"

The staff reviewed the LLHS for compliance with the requirements of GDC 2, with respect to its design for protection against the effects of natural phenomena. Compliance with the requirements of GDC 2 is based on the adherence to Regulatory Position C.1 and C.2 of RG 1.29.

The LLHS is used in the refueling cavity located in the pre-stressed concrete containment vessel (PCCV), in the SFP, new fuel storage pit, fuel inspection pit, spent fuel cask pit, spent fuel cask wash-down pit, refueling canal and in the receiving area located in the RB refueling area. The PCCV and RB are Seismic Category I structures. Also included in LLHS, is the seismic Category I fuel transfer tube which penetrates the PCCV from the refueling canal in the fuel handling area to the refueling cavity in the PCCV enabling the transfer of fuel assemblies between the two areas. Design layout drawings of the LLHS are provided in DCD Tier 2 Figure 9.1.4-1, "Plan View of Light Load Handling System" and Figure 9.1.4-2, "Section View of Light Load Handling System."

DCD Section 9.1.4.1, "Design Basis," states that the LLHS components involved in grappling, latching, translating, rotating, supporting, or hoisting fuel assemblies are designed to assure no structural failure of any part of the handling equipment would result in dropping or damaging a fuel assembly. In Revision 1 of the DCD, these components were designated as Seismic Category I and designed in accordance with DCD Section 3.7, "Seismic Design," and Section 3.9, "Mechanical Systems and Components." However, DCD Tier 1 Table 2.7.6.4-1, "Light Load Handling System Characteristics," listed the spent fuel cask handling crane suspension hoist, which handles new fuel assemblies, as Seismic Category II. Therefore, the staff submitted RAI 200-1983, Question 9.1.4-01, asking the applicant to explain the statement in DCD Section 9.1.4.1, which defines all components involved in fuel handling as Seismic Category I.

In its response to RAI 200-1983, Question 9.1.4-01, dated April 23, 2009 (MHI Ref: UAP-HF-09197), the applicant updated DCD Tier 1 Table 2.7.6.4.1 to be consistent with Tier 2 Table 3.2-2, "Classification of Mechanical and Fluid Systems, Components, and Equipment," of the DCD. Since Table 3.2-2 contains seismic classification of LLHS components, the applicant proposed to resolve the inconsistencies between Table 3.2-2 and Section 9.1.4 by replacing the seismic details in Section 9.1.4 with a reference to Table 3.2-2.

The staff determined that the proposed changes to Tier 2 Section 9.1.4, and Tier 1 Section 2.7.6 are acceptable, since they properly reference Table 3.2-2 as the location for the LLHS seismic classification. The staff has confirmed that the DCD was revised as committed in the RAI response, and therefore, the issue is resolved, and the RAI is considered to be closed.

Table 3.2-2 of DCD Revision 1 provides seismic classifications for some LLHS components, but did not include all LLHS equipment. The applicant listed the SFP and the new fuel pit but did not list the fuel inspection pit, new fuel elevator and the various tools described in DCD Tier 2, Section 9.1.4 and the flanges and valve associated with the fuel transfer tube. Therefore, the staff submitted RAI 200-1983, Question 9.1.4-02, asking the applicant to explain why all the SSCs of the LLHS are not listed in DCD Table 3.2-2.

In its response, dated April 23, 2009 (MHI Ref: UAP-HF-09197), the applicant acknowledged the need for more detail in Table 3.2-2 by proposing the addition of the fuel inspection pit, fuel transfer system (excluding fuel transfer tube), and the new fuel elevator to Table 3.2-2. The applicant also defined the various tools detailed in Tier 2 Section 9.1.4.2.1, as tools associated with the fuel handling system and stated that they should not be regarded as SSCs and would not be added in Table 3.2-2. In October 2009, the applicant submitted Revision 2 of the DCD which incorporated the applicant's response to RAI 200-1983, Question 9.1.4-02**,** and also included the classification for the tools into Table 3.2-2. The staff finds the revised DCD Tier 2 Table 3.2-2 acceptable, since the changes result in the LLHS design to be consistent with ANSI 57.1. Based on the applicant's response, and the revised Table 3.2-2, the staff finds that the concerns raised by RAI 200-1983, Question 9.1.4-02 have been adequately addressed and, therefore, RAI 200-1983, Question 9.1.4-01 is considered to be closed.

The fuel transfer tube penetrates the PCCV wall connecting the fuel handling canal in the RB with the refueling canal in the interior of the PCCV. The fuel transfer tube penetration is sealed with the PCCV wall similarly to other mechanical penetrations. The staff submitted RAI 200-1983, Question 9.1.4-03, asking the applicant to clarify any discrepancy between the safety classification of the LLHS in DCD Tier 1, Section 2.7.6.4.1 and ANSI/ANS 57.1.

In its response, dated April 23, 2009 (MHI Ref: UAP-HF-09197), the applicant confirmed that the LLHS, except for the fuel transfer tube and blind flange (designated as Safety Class 2), is non-safety related and proposed revising DCD Tier 1 Section 2.7.6.4.1, and Tier 2 Section 9.1.4.2, to indicate accordingly. In October 2009, the applicant submitted Revision 2 of the DCD which incorporated the applicant's response to RAI 200-1983, Question 9.1.4-03. The staff has confirmed that the DCD has been revised as committed in the RAI response and finds the safety classification for the LLHS in Tier 2 Section 9.1.4, and Tier 1 Section 2.7.6, is in accordance with ANSI 57.1 and are therefore considered to be acceptable. Therefore, RAI 200-1983, Question 9.1.4-03 is closed.

The equipment that make up the LLHS is non-safety related, with the exception of fuel transfer tube and blind flange, and designed to Seismic Category I or II, and is housed in Seismic Category I structures, which are designed to withstand earthquakes, floods, and tornados. The fuel transfer tube and blind flange are Seismic Category I and are in accordance with position C1 of RG 1.29. The cranes that makeup the LLHS, were reviewed, and it was determined that the cranes are designed to retain their loads during and following a SSE in accordance with Position C2 of RG 1.29. DCD Tier 2, Section 3.2.1 states that the applicant meets the requirements of GDC 2 of 10 CFR 50 Appendix A by using the guidance provided in RG 1.29, for identifying and classifying SSCs. Based on the above review, the staff concludes that the LLHS is designed in accordance with Positions C1 and C2 of RG 1.29, and meets the requirements of GDC 2 as they relate to the LLHS design for protection against the effects of natural phenomena.

B. GDC 5, "Sharing of Structures, Systems, and Components"

The LLHS system of the US-APWR is not shared between multiple units in accordance with DCD Tier 2, Section 9.1.4.1, which states "…the LLHS in the US-APWR is not shared between multiple units." Therefore, the provisions of GDC 5 are not applicable to the US-APWR standard plant design.

C. GDC 61, "Fuel storage and handling and radioactivity control"

The staff reviewed the LLHS for compliance with the requirements of GDC 61, with respect to its design for protection as it relates to radioactive release as a result of fuel damage and the avoidance of excessive personnel radiation exposure. Compliance with the requirements of GDC 61 is based in part on the guidelines of ANSI/ANS 57.1, "Design Requirements for Light Water Reactor Fuel Handling Systems."

The LLHS design incorporates features (electrical interlocks, limit switches, mechanical stops) to provide protection against damage to fuel due to excessive loads or fuel drops, and provide personnel protection from excessive radiation exposure.

The interlocks provided for the LLHS are as defined in ANS 57.1, Paragraph 6.3.1.1, and in Table 1 for the fuel handling machine, the new fuel elevator, the Fail-To-Start (FTS) including upenders, and the refueling machine.

DCD Tier 2 Section 9.1.4.1, states that the LLHS is designed with the "Ability to perform periodic inspections and testing of components important to safety through configuration of the LLHS and, where necessary, the ability to isolate the equipment from shield waters." As it was unclear to the staff what the applicant meant by this statement, the staff submitted RAI 200-1983, Question 9.1.4-04 requesting the applicant to clarify the meaning of the ability to isolate equipment from shield waters and to explain how that is performed.

In its response, dated April 23, 2009 (MHI Ref: UAP-HF-09197), the applicant clarified the meaning of "isolate the equipment from shield waters" by indicating that all LLHS components, including those that are immersed in water for shielding, are designed to be removed from the water (following decontamination) for as necessary inspections and testing. The applicant revised DCD Section 9.1.4.1, to clarify that the LLHS is configured to enable components to be safely removed for inspection and testing. Based on the applicant's clarification that the capability exists to remove components from the water following decontamination for inspection and testing and incorporation into Section 9.1.4 of the DCD, RAI 200-1983, Question 9.1.4-04 is considered to be closed.

Maintenance of acceptable shielding requirements is achieved by designing and configuring the LLHS to comply with ANSI/ANS 57.1-1992. As indicated in Section 9.1.4.1 of the DCD, radiation shielding is provided by structural features such as concrete walls, floors, and/or barriers of the refueling area of the RB, or by maintaining a minimum coverage of water (with an appropriate concentration of BA) over irradiated fuel. As indicated in Section 12.3.2.2.4, "This depth of water limits the dose at the water surface to less than 2.5 mrem/h for an assembly in a vertical position." This dose rate limit adheres to the criteria stated in ANSI/ANS 57.1-1992, Subsection 6.3.4.1.5, which states, "Fuel handling equipment shall be designed so that the operator will not be exposed to >2.5 mrem/h from an irradiated fuel unit, control component, or both, elevated to the up position interlock with the pool at normal operating water level." In addition, the staff's evaluation of the radiation dose in the fuel handling area is discussed in Chapter 12 of this SE. Since the design is in accordance with ANSI/ANS 57.1, the staff finds it acceptable with respect to personnel radiation exposure.

The refueling machine is used to transport fuel assemblies between the FTS and the reactor vessel within the confines of the refueling cavity. Fuel assemblies are raised into a mast tube for protection during transport between the FTS and precisely indexed over a fuel assembly in the reactor core. The mast tube contains a sipping system used to detect leaking fuel. The refueling machine also contains an auxiliary hoist used in control rod drive shaft unlatching operation. The applicant stated in Section 9.1.4.2.1.1, "Refueling machine," that electrical interlocks, limit switches and mechanical stops are utilized to prevent damage to a fuel assembly, to assure appropriate radiation shielding depth below the water level in the refueling cavity, and to monitor the fuel assembly load for imparted loads greater than the nominal weight of the fuel assembly. The refueling machine is classified as nonsafety-related and Seismic Category II.

The fuel transfer system consists of a rail mounted transfer container car which transports fuel assemblies through transfer tube between the refueling area of the RB and containment vessel (C/V). DCD Section 9.1.4.2.1.6, "Fuel Transfer Tube," describes the fuel transfer tube as having a gate valve on the refueling area end of the transfer tube and a blind flange on the C/V end. The containment boundary is a double-gasket blind flange at the refueling canal end. The expansion bellows are independent of the containment boundary; however, they maintain water seals by accommodating differential movement of the structures. DCD Section 3.8.1.1.4 indicates the fuel transfer tube penetration is sealed with the PCCV wall similar to other mechanical penetrations. Initially, DCD Tier 1, Section 2.7.6.4, "Light Load Handling System," provided classification of fuel transfer tube and fuel transfer tube blind flange as non-safety and seismic Category I. Yet, Table 3.2-2 , entitled "Classification of Mechanical and Fluid Systems, Components, and Equipment," of DCD Tier 2 listed the fuel transfer tube as safety related, Equipment Class 2. Therefore, the staff submitted RAI 200-1983, Question 9.1.4-05, requesting the applicant to clarify DCD Tier 1, regarding safety classification of the LLHS, and provide component classification information for the transfer tube gate valve and double-gasket blind flange in DCD Tier 2, Table 3.2-2.

In its response, dated April 23, 2009 (MHI Ref: UAP-HF-09197), the applicant indicated that this inconsistency was addressed in its response to RAI 200-1983, Question 9.1.4-03 (see above). The applicant also indicated that the transfer tube gate valves and double-gasket blind flange will be designed to meet Seismic Category I and equipment Class 2, which is in accordance with ANSI 57.1. Based on the above, the staff concluded that the proposed corrections aligning the LLHS safety classification of DCD Tier 1 Section 2.7.6.4.1 with Tier 2 Table 3.2-2 are satisfactory and are addressed in response to RAI 200-1983, Question 9.1.4-03 above. Therefore, the staff considers RAI 200-1983, Question 9.1.4-05, to be resolved.

The fuel handling machine transports fuel assemblies between the fuel elevator and the SFP within the confines of the refueling area pits and fuel transfer canal. The spent fuel assembly handling tool is used for transferring new and irradiated fuel assemblies at the appropriate depth below the shielding water. The applicant indicated that the electrical interlocks, limit switches, and mechanical stops, having the same function for the refueling machine, are also provided for the fuel handling machine. DCD Tier 2 Section 9.1.4.2.1.2, "Fuel Handling Machine," stated that the fuel handling machine traverses the length of the refueling cavity. Since the refueling cavity is in containment and the fuel handling machine is in the RB, the staff submitted RAI 200-1983, Question 9.1.4-06, asking the applicant to explain the traversing range of the fuel handling machine and its ability to traverse the refueling cavity. In addition, the fuel handling machine has an auxiliary hoist with a load limiting device to prevent the hoist from exerting excessive force. The auxiliary hoist has the load capacity to lift a fuel assembly, but is configured to preclude latching on to the fuel assembly. However, the applicant did not provide the purpose of the auxiliary hoist. Therefore the staff requested the applicant in RAI 200-1983, Question 9.1.4-06, to also state the purpose of the auxiliary hoist and revise the DCD accordingly.

In its response, dated April 23, 2009 (MHI Ref: UAP-HF-09197), the applicant acknowledged that the fuel handling machine consists of two motorized end trucks, which traverse the length of the SFP, the cask pit and the fuel inspection pit, but not the refueling cavity. The applicant also detailed the purpose and use of the fuel handling machine auxiliary hoist as being limited to handling inserts for spent fuel assemblies and pool-separating gates.

The staff concludes that the RAI response provides an adequate explanation of the traversing range of the fuel handling machine. In addition, the staff finds that the proposed description of the purpose and use of the auxiliary hoist also includes sufficient detail. Therefore, based on the above, RAI 200-1983, Question 9.1.4-06, is considered to be closed. However, the applicant failed to propose any modification to define the purpose and use of the auxiliary hoist on the fuel handling machine in the DCD. Therefore, the staff submitted RAI 555-4385, Question 9.1.5-17, requesting the applicant to clearly define the function of the auxiliary hoist and update the DCD accordingly.

In its response to RAI 555-4385, Question 9.1.4-17, dated June 4, 2010, the applicant redefined the purpose and use of the auxiliary hoist to handle the inserts for a new or a spent fuel assembly using an appropriate handling tool. The auxiliary hoist also handles the gates separating the various pits (pools). The auxiliary hoist has the load capacity to lift a new or a spent fuel assembly using a spent fuel assembly handling tool, as backup to the mast tube assembly. In its response dated June 4, 2010, the applicant proposed to revise the DCD to state the function of the auxiliary hoist of the fuel handling machine. The staff concludes that the RAI response is acceptable based on the proposed description of the auxiliary hoist including sufficient detail to define its function. This staff confirmed that the proposed markups from the response to RAI 555-4385, Question 9.1.4-17, have been incorporated into the DCD. Therefore, RAI 555-4385, Question 9.1.5-17, is considered to be closed.

DCD Section 9.1.4.2.2.2, briefly describes the fuel handling LLHS process involved in unloading irradiated fuel from the reactor vessel and relocating it to the SFP using the refueling machine. This section also specifies that irradiated and new fuel assemblies are individually lifted from a SFR by using the fuel handling machine, transferred to the up ender, and transferred to inside containment. However, details regarding how the new fuel is placed in the SFRs were not clearly defined. The application did not clearly describe the integrated use of the new fuel storage pit, fuel inspection pit and the SFP in the processes that accept new fuel and for the refueling operation. In addition, the application did not describe the purpose of the fuel inspection pit. Therefore, the staff submitted RAI 200-1983, Question 9.1.4-07, requesting the applicant to clearly describe the integrated use of the new fuel storage pit, fuel inspection pit and the SFP in the processes that accept new fuel and for the refueling.

In its response, dated April 23, 2009 (MHI Ref: UAP-HF-09197), the applicant provided a detailed description of the process for transferring new fuel assemblies from the new fuel storage pit to the reactor. The applicant stated that the primary purpose of the fuel inspection pit is to allow as-needed underwater visual inspections of the irradiated fuel removed from the reactor core. The response stated that the new fuel assembly is lifted using the fuel handling machine auxiliary hoist. This appeared to contradict the answer provided for RAI 200-1983, Question 9.1.4-06 (see above), which limits the use of the auxiliary hoist of the fuel handling machine to handling inserts for spent fuel assemblies and pool-separating gates.

As a result, the staff could not fully evaluate the balance of the new fuel movement process until the confusion involving the exact purpose and uses, including specific limitations, of the auxiliary hoist were fully explained. The staff found the description of the fuel inspection pit satisfactory. However, the applicant failed to propose any language for inclusion in the DCD for either the description of the movement of new fuel or the purpose for the fuel inspection pit. Therefore, the staff submitted RAI 555-4385, Question 9.1.4-18, requesting the applicant to clarify the use of the auxiliary hoist and modify the DCD accordingly. The applicant's response to RAI 555-4385, Question 9.1.4-18, dated June 4, 2010, proposed details to incorporate into the DCD in regards to new fuel handling and inspection pit uses. The staff finds the level of detail proposed in the RAI response provides an adequate description of the new fuel receipt process and fuel inspection pit. The staff confirmed that the DCD was updated accordingly and, therefore, RAI 200-1983, Question 9.1.4-07, and RAI 555-4385, Question 9.1.4-18, are closed.

Based on its review of the LLHS above, the staff concludes that the design of the LLHS complies with the guideline of ANSI 57.1-1992. Therefore, the staff concludes that the LLHS meets the requirements of GDC 61 with respect to the radioactivity release as a result of damage and the avoidance of excessive personnel radiation exposure.

D. GDC 62, "Prevention of criticality in fuel storage and handling"

The staff reviewed the LLHS for compliance with the requirements of GDC 62, with respect to its design for prevention of criticality in fuel handling systems. Compliance with the requirements of GDC 62 is based in part on the guidelines of ANSI/ANS 57.1.

As indicated in DCD Section 3.1.6.3, "Criterion 62 - Prevention of Criticality in Fuel Storage and Handling," fuel storage and handling systems are provided to preclude accidental criticality for new and spent fuel. The restraints, interlocks, and geometrically safe physical arrangement are provided for the safe handling and storage of new and spent fuel with respect to critically prevention. Layout of the fuel handling area is such that a spent fuel cask cannot traverse the SFP.

As indicated in Section 9.1.1.1 of the DCD, criticality is precluded by adequate design of fuel handling and storage facilities and by administrative control procedures.

The applicant has stated that the LLHS has been designed to comply with ANS 57.1-1992, which states that fuel handling equipment shall be designed to ensure that subcriticality is maintained with the equipment fully loaded with fuel and the pool flooded with unborated water. In RAI 200-1983, Question 9.1.4-08, the staff requested the applicant to specify how the above listed design objective is achieved when moving fuel with each piece of the following LLHS equipment: the refueling machine, fuel handling machine, new fuel elevator, fuel transfer system, and the spent fuel cask handling crane suspension hoist.

In its response, dated April 23, 2009 (MHI Ref: UAP-HF-09197), the applicant explained that the LLHS equipment is designed to handle one fuel assembly at a time with sufficient surrounding space to ensure that subcriticality is maintained, and incorporated a statement to that effect, into Section 9.1.4.1 of DCD Revision 2. Based on the applicant's described method to ensure subcriticality, RAI 200-1983, Question 9.1.4-08 is considered to be closed. The staff confirmed that the DCD was updated accordingly.

Acceptance for meeting the relevant aspects of GDC 62 is based in part on the guidelines of ANSI/ANS 57.1-1992. Since the LLHS is designed to ensure that subcriticality is maintained with the equipment fully loaded with fuel and the pool flooded with unborated water, and since the LLHS is designed to retain its load in the event of an SSE, (not failing in a manner to cause damage to fuel or permit criticality), the LLHS designed is judged to be compliant with the guidelines provided in ANSI/ANS 57.1-1992. Therefore, based on the review of the LLHS above, the staff concludes that the LLHS meets the requirements of GDC 62 as it relates to prevention of criticality accidents.

E. Reactor Cavity Seal

To address operating experience considerations, Inspection and Enforcement (IE) Bulletin 84-03, "Refueling Cavity Water Seal," was issued to address the potential failure of the refueling cavity seals to assure that fuel uncovery, while refueling, remains an unlikely event. The bulletin required licensees to evaluate the potential for and consequences of a refueling cavity seal failure. Additional information concerning refueling cavity seal failures was provided by Information Notice (IN) 84-93, "Potential for Loss of Water from the Refueling Cavity." IN 84-93 noted that refueling cavities can also be drained due to failures associated with other seals and as a consequence of valve misalignments. Inadvertent drain down of the refueling cavity can result in a loss of cooling for fuel in transit and may cause a loss of water inventory and cooling for fuel in the buffer pool. Because the water inventory in the refueling cavity is also needed for shielding purposes, high radiation levels can also result from exposed fuel and reactor components. 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 61 "Fuel Storage and Handling and Radioactivity Control," requires that the system design for fuel storage and handling of radioactive materials shall include the capability to prevent reduction in fuel storage coolant inventory under accident conditions. GDC 63 "Monitoring Fuel and Waste Storage," requires that monitoring systems shall be provided to detect conditions that could result in the loss of decay heat removal, to detect excessive radiation levels, and to initiate appropriate safety actions.

The staff reviewed the DCD and determined that it was not clear that the applicant had addressed the operational experience regarding refueling cavity draindown. Therefore, the staff issued RAI 507-3993, Question 9.1.4-16, RAI 633-4857, Question 9.1.4-21, and RAI 721-5535, Question 9.1.4-22, requesting the applicant to address operating experience considerations associated with IE Bulletin 84-03.

The applicant provided responses to the staff's RAIs in letters dated February 22, 2010, October 21, 2010; and April 20, 2011, respectively. The applicant's latest RAI response proposed DCD changes to incorporate additional information pertaining to IE Bulletin 84-03 in Tier 2 Subsection 9.1.4.2.1.13 and Subsection 9.1.4.2.2.2. The applicant's response to the RAIs and the staff's evaluation of these responses are discussed below. The staff is tracking the incorporations of these DCD changes, as described in response to the RAI 721-5535, Question 9.1.4-22, as **Confirmatory Item 9.1.4-22**.

1. Refueling Seals

   The RAI response states that the purpose of the permanent cavity seal (PCS) is to maintain water level in the refueling cavity during refueling operation by sealing the annular gap between the reactor vessel flange and the refueling floor. It is permanently installed, made of stainless steel (for corrosion resistance), and

PCS fabrication and installation are in accordance with applicable codes and standards. A leak detection system is provided with the capability to continuously monitor any leakage that may occur through the seal. The PCS is physically protected from dropped objects by a stainless steel guard plate. The PCS will be monitored for leakage and periodic maintenance and inspections will be conducted. The PCS is designed such that any leakage that may occurs will be readily identified and corrected. The RAI response further states that the procedures specified in Tier 2, Section 9.1.4.2.2.2, will ensure that the PCS is properly maintained over the life of the plant.

The staff reviewed the RAI response 887-6261, Question 9.1.4-23 and determined that the cavity ring design is sufficiently robust to preclude a catastrophic failure of the seal during normal or abnormal operations and during a seismic event. The evaluation of the applicable design codes and standards and seismic design are evaluated in Chapter 3, Section 3.2.2. The evaluation of the connection of the cavity seal to the vessel is evaluated below. The seal integrity is protected from the impact of a fuel assembly by a guard plate, and a leak detection system is used to monitor and identify seal degradations before it could spread and jeopardize the seal integrity. Therefore, the staff finds that the cavity ring is designed to prevent catastrophic seal failure under normal and accident conditions.

On January 10, 2012, the staff issued RAI 887-6261 Question 9.1.4-23 to request that the applicant (1)describe in detail the permanent cavity seal (PCS) and seal ledge, identifying the materials used, (2)identify any fasteners, bolts and welds used in the PCS, (3)describe in detail the connections between the PCS and the reactor vessel, especially any welding design considerations and controls imposed on welding, and (4)justify the classification of codes and standards applicable to the PCS as “codes and standards as in defined bases” rather than “ASME Code, Section III, Class 3”. The applicant responded on February 8, 2012, but the staff has not had time to evaluate the applicant’s response. Therefore, the staff identifies an Open Item for the staff to review the applicant’s response to RAI 887-6261 Question 9.1.4-23.

2. Refueling Cavity Drainage Paths

In addition to the flow paths associated with the seals discussed in (A) above, the RAI responses discussed other flow paths that could drain the refueling cavity. These other flow paths include the fuel transfer tube, cask pit gate, fuel inspection pit gate, and cavity drain valve.

The fuel transfer tube is designed as a seismic Category I structure that is provided with isolation capability between the reactor building and the fuel building. The cask pit gate, fuel inspection pit gate, and cavity drain valve are designed as Seismic Category I, the integrity of these components is periodically inspected, and a catastrophic failure of these components is not expected.

The RAI response also states that valve misalignments can cause the reactor (and refueling cavity) to drain when aligning systems for operation and establishing maintenance boundaries. However, these evolutions are performed in accordance with strict procedural controls that are established to prevent and identify system misalignment.

The staff evaluation of the RAI response confirmed that the DCD has identified the above mentioned components as seismic Category I. The seismic design of these structures ensures that the refueling cavity will maintain its integrity during and following a SSE. The design of the fuel transfer tube is described in DCD Tier 2 Section 3.8, and the staff evaluation of these designs is presented in Section 3.8 of this SE. Consequently, no further evaluation of fuel transfer tube is provided in this section.

The staff evaluated the RAI response and determined that the valve misalignments can cause the reactor (and refueling cavity) to drain when aligning systems for operation, establishing maintenance boundaries, or by operator error. However, these evolutions are performed in accordance with strict procedural controls that are established as specified in Tier 2 Section 13.5.2, and are subject to NRC inspection. Based on operating experience, the staff finds that this approach has been effective in preventing catastrophic drainage from systems connected to the reactor vessel. Therefore, the staff finds that there is reasonable assurance that valve misalignments will not pose a threat to the refueling cavity water inventory or the inventory of water in the reactor vessel.

3. Refueling Cavity Leakage Detection

In its response to the staff's RAI dated April 20, 2011, the applicant proposed to modify Tier 2 Section 9.1.4.2.1.13, to include the system description of the leakage detection system credited to identify PCS degradation. During refueling, the refueling cavity pool level is constantly monitored and alarms are provided to detect a drop in level. Consequently, plant operators will be made aware of any significant leakage from the refueling cavity that develops while the reactor is being refueled and will be able to take corrective actions as appropriate.

The staff finds that the use of a leakage detection system will enable operators to monitor refueling cavity water level and alert the operators of a loss of inventory early enough to provide the operator sufficient time to position the fuel assembly in movement into a safe location before the water level drops below the minimum level needed to provide sufficient radiation shielding. Dose considerations associated with refueling operations are evaluated in Section 12.4 of this SE.

4. Impact and Mitigation of Refueling Cavity Leakage

The RAI response proposed DCD changes to Tier 2 Section 9.1.4.2.1.13, and Section 9.1.4.2.2.2, in order to discuss the impact and mitigation of refueling cavity leakage. These modifications indicate that a rapid draindown of the refueling cavity is not likely to occur. The response states that the level indication and annunciation are provided to alert operators to any leakage from the refueling cavity that develops, and any leakage that does occur would be well within the makeup capability that is provided by the RWSP via the refueling water recirculation pumps. Fuel in transit can be quickly placed into a safe location, the containment rack or back into the reactor vessel.

The staff evaluated the RAI response and determined that the refueling cavity and connected openings are designed with features that preclude the rapid drain down of the reactor cavity. The staff also determined that any refueling cavity leakage will be less than the available makeup capability. Therefore, cooling for the fuel bundle in transit and for those stored in the reactor vessel or the fuel transfer tube will not be compromised, and shielding that is needed for reactor components and spent fuel will be maintained.

5. Procedural Controls for Maintaining Refueling Cavity Integrity

The applicant's proposed modifications to DCD Tier 2 Section 9.1.4.2.2.2, "Reactor Refueling Operations," states that operating procedures will contain measures for performing maintenance, and procedures related to refueling cavity integrity will be included in this plan (among others). For example, some of the procedures include procedures for monitoring refueling cavity seal leakage, responding to refueling cavity drain down events, and for performing periodic maintenance and inspection of the refueling cavity seal and other seals and plugs. The procedures specified in Tier 2 Section 9.1.4.2.2.2, will ensure that refueling cavity seals are periodically inspected and properly maintained, valve alignment conditions are properly specified and controlled, operators are cognizant of water inventory in the refueling cavity and are alerted to any significant leaks that develop, and appropriate actions are specified and taken to preserve the integrity of the refueling cavity and maintain cooling for spent fuel during the conduct of refueling activities.

The staff evaluated the RAI response and found that these procedures will provide adequate instructions for maintaining refueling cavity integrity and spent fuel cooling when the reactor is being refueled. Therefore, the procedural controls that are called for in Tier 2 Section 9.1.4.2.2.2 are necessary and appropriate, and are considered to be acceptable by the NRC staff.

The information provided in response to RAI 507-3993, Question 9.1.4-16, RAI 633-4857, Question 9.1.4-21, and RAI 721-5535, Question 9.1.4-22, the DCD proposed mark-ups included in the RAI response, and the staff evaluation discussed above assure that during the conduct of refueling operations **(pending resolution of Confirmatory Item 9.1.4-22)**, the integrity of the refueling cavity, cooling for spent fuel bundles that are in transit or located in the fuel transfer tube, and shielding that is needed for reactor components and spent fuel will continue to be maintained. Therefore, the staff finds that the refueling cavity design adequately addresses the operational experience related to IE Bulletin 84-03 and IN 84-93, and has adequately addressed the requirements of GDC 61 and GDC 63 in terms of preventing a reduction in fuel storage coolant inventory under accident conditions and detecting conditions that could result in the loss of decay heat removal and excessive radiation levels.

F. Miscellaneous

As described in DCD Section 9.1.4.2.2.1, the new fuel containers are set on the operating floor. The suspension hoist is then used to remove new fuel from the shipping container and is then stored it in the new fuel storage pit. During this operation, the new fuel assemblies are suspended using a short fuel handling tool to permit surface inspection prior to being placed into a new fuel storage rack. The staff was not able to determine whether the guidelines of SRP 9.1.4.III.1, which specify that the LLHS physical arrangement for stored fuel and fuel handling areas, are to be described sufficiently to establish that the various handling operations can be performed safely. Therefore, the staff submitted RAI 200-1983, Question 9.1.4-10, requesting the applicant to clearly outline the handling process of new fuel after it is received into the new fuel storage pit and whether new fuel is stored in the new fuel pit or the SFP prior to load. The staff also asked the applicant to provide a description of how the fuel inspection pit and new fuel elevator are used during new fuel receipt operation.

In its response, dated April 23, 2009 (MHI Ref: UAP-HF-09197), the applicant referred to the response of RAI 200-1983, Question 9.1.4-07, for a description of the handling process of new fuel after its receipt into the new fuel storage pit. Since the applicant has addressed this in RAI 200-1983, Question 9.1.4-07 above, RAI 200-1983, Question 9.1.4-10, is considered to be closed.

As indicated in Section 9.1.4.2.2.4, “Spent Fuel Shipment,” spent fuel can be removed from the SFP and placed into spent fuel casks for removal from the plant. The spent fuel transfer and cask handling components involved are the spent fuel handling crane, suspension hoist, cask washdown pit, and cask pit. After raising the spent fuel cask to the refueling floor, the spent fuel cask is washed in the cask washdown pit.

After washdown, the spent fuel cask is placed into the cask pit, where it is loaded with spent fuel assemblies from the SFP. After the cask is fully loaded, the cask is moved to the cask washdown pit.

Initial Plant Test Program

As discussed in Section 14.2 of this SE, the staff reviewed the applicant’s initial test program in accordance with the review guidance contained in Section 14.2, “Initial Plant Test Program - DC and New License Applicants,” Revision 3 of the SRP, and RG 1.68 and RG 1.206. The staff’s evaluation of the initial plant test program is documented in Section 14.2 of this SE. The evaluation below is an extension of the staff’s evaluation in Section 14.2.

The initial test program will have preoperational test 14.2.12.1.86, “Fuel Handling System Preoperational Test,” to demonstrate operation of the fuel handling system control circuits and associated interlocks, and to verify transfer of a dummy assembly from the new fuel storage pit to the refueling machine in containment and back to the SFP. Fuel handling machines will be load tested to 125 percent of rated load.

As specified in DCD Section 14.2.12.1.86, the applicant commits to testing the refueling machine, new fuel elevator, and fuel handling machine testing in accordance with the tests specified in ASME NOG-1 and ASME B30.20-2006, as applicable. Therefore, the staff finds the Fuel Handling System (FHS) initial plant testing acceptable.

Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC)

Tier 1 of the US-APWR DCD provided a general overview of the system and included the LLHS Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC). The LLHS ITAAC is designed to meet the requirements of 10 CFR 52.47(b) (1), to ensure that the as-built system complies with the approved system design in the DCD. The LLHS ITAAC is described in Tier 1 Table 2.7.6.4-2, “Light Load Handling System Inspections, Tests, Analyses, and Acceptance Criteria.”

Revision 1 of the DCD Tier 2, Table 3.2-2, entitled “Classification of Mechanical and Fluid Systems, Components, and Equipment,” listed the refueling machine, fuel handling machine and other equipment as equipment Class 2 or 3, which are safety related. However, the safety related functions are not described in the DCD Tier 1, Section 2.7.6.4, ”Light Load Handling System” and safety related functions should have ITAAC identified in Table 2.7.6.4-2., entitled “Light Load Handling System Inspections, Tests, Analyses, and Acceptance Criteria.” Therefore, the staff submitted RAI 200-1983, Question 9.1.4-13 asking the applicant to explain why the application does not include ITAAC for all safety related SSCs and safety related functions, including the fuel transfer tube that serves as a part of the primary reactor containment and the fuel handling machine.

In its response, dated April 23, 2009 (MHI Ref: UAP-HF-09197), the applicant referred to Design Commitment Numbers 1, 2b, 3b, and 4b of DCD Tier 1 Table 2.11.2-2, “Containment Isolation System Inspections, Tests, Analyses, and Acceptance Criteria,” to describe the ITAAC for the fuel transfer tube as part of the primary reactor containment. The applicant also proposed to include an ITAAC for the fuel handling machine in Tier 1 Table 2.7.6.4-2, similar to that of the refueling machine. In addition, the applicant referred to RAI 184-1912, Question 14.03.07-31, which included other proposed changes to the DCD Revision 1 Table 2.7.6.4-2. As an update to Table 2.7.6.4-2, the applicant proposed an additional ITAAC requirement that provided a reference to Tier 1 Table 2.11.2-2 to describe the ITAAC for the fuel transfer tube as part of the primary reactor containment. Since ITAAC for the fuel transfer tube are included in containment isolation ITAAC Table 2.11.2-2, RAI 555-4385, Question 9.1.4-20, is closed.

The staff’s evaluation of the ITAAC that are specified in Table 2.7.6.4-2 of this report, and this section of the staff’s evaluation confirms that the appropriate ITAAC are specified for the light load handling systems consistent with the approach that is described in Tier 2, DCD Section 14.3

Based on the information provided in Table 2.7.6.4-2, the staff concludes that the US-APWR LLHS ITAAC meet 10 CFR 52.47(b)(1), which requires that a DC 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 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

9.1.4.5 Combined License Information Items

There are none identified in the US-APWR DCD for Section 9.1.4.

9.1.4.6 Conclusions

The staff is tracking RAI 887-6261, Question 9.1.4-23 as an Open Item until the staff completes its review.

The LLHS includes all components and equipment for moving fuel and other related light loads between the receiving area, storage areas, and reactor vessel. Pending resolution of the confirmatory items, the staff finds that the LLHS design is in compliance with GDC 2, 61, and 62 and with 10 CFR 52.47(b)(1). In addition, the staff concludes that GDC 5 is not applicable to the US-APWR design since the LLHS is not shared between multiple nuclear power units.

9.1.5 Overhead Heavy Load Handling System

9.1.5.1 Introduction

The heavy loads handling systems consist of all components and equipment for moving all heavy loads (i.e., loads weighing more than one fuel assembly and its handling device) at the plant site. The main emphasis in the review is on critical load handling where inadvertent operations or equipment malfunctions, separately or in combination, could cause a release of radioactivity, a criticality accident, inability to cool the fuel within the reactor vessel or SFP, or could prevent a safe shutdown of the reactor.

9.1.5.2 Summary of Application

DCD Tier 1: The DCD Tier 1 information associated with this section is found in Tier 1, Section 2.7.6.5 of the US-APWR DCD.

DCD Tier 2: The applicant has provided a Tier 2 description of overhead heavy load handling system (OHLHS) in Section 9.1.5 of the US-APWR DCD, Revision 3, summarized here in part, as follows:

> The primary pieces of equipment used in the OHLHS are the spent fuel cask handling crane in the fuel handling area and the polar crane in the PCCV. Other OHLHS equipment includes monorail type hoists, bridge cranes, and jib cranes. The OHLHS also includes equipment accessories (e.g., slings, and hooks, etc.) instrumentation, physical stops and/or electrical interlocks, and associated administrative controls. The physical arrangement of the heavy load handling system for stored fuel and safe shutdown equipment is shown in Figure 9.1.5-1 through Figure 9.1.5-4. The specifications for the spent fuel cask handling crane and the polar crane are given in Table 9.1.5-1 and Table 9.1.5-2.

ITAAC: The ITAAC associated with Tier 2, Section 9.1.5 are given in Tier 1, Section 2.7.6.5.2.

TS: There are no TS for this area of review.

9.1.5.3 Regulatory Basis

The relevant requirements of the Commission's regulations for this area of review, and the associated acceptance criteria, are given in Section 9.1.5 of NUREG-0800, the SRP, and are summarized below. Review interfaces with other SRP sections can be found in Section 9.1.5.I of NUREG-0800.

1. GDC 1 "Quality Standards and Records," of Appendix A, 10 CFR Part 50, as it relates to the design, fabrication, and testing of SSCs important to safety to maintain quality standards.

2. GDC 2, "Design Basis for Protection Against Natural Phenomena," as it relates to the ability of structures, equipment, and mechanisms to withstand the effects of earthquakes.

3. GDC 4, “Environmental and Dynamic Effects Design Bases,” as it relates to protection of safety-related equipment from the effects of internally-generated missiles (i.e., dropped loads).

4. GDC 5, “Sharing of Structures, Systems, and Components,” as it relates to safety-related structures not being shared among nuclear power units, unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions.

5. 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, the facility has been constructed and will operate in conformity with the COL, the provisions of the Atomic Energy Act of 1954, and the NRC’s regulations.

Acceptance criteria adequate to meet the above requirements are:

1. Acceptance for meeting the relevant aspects of GDC 1 is based in part on NUREG-0554, “Single-Failure-Proof Cranes for Nuclear Power Plants,” for overhead handling systems and ANSI Standard N14.6, “Special Lifting Devices for Shipping Containers Weighing 10000 pound (4500 kg) or More,” or American Society of Mechanical Engineers (ASME) Std B30.9, “Slings” for lifting devices.

2. Acceptance for meeting the relevant aspects of GDC 2 is based in part on Position C.2 of RG 1.29 “Seismic Design Classification,” and Section 2.5 of NUREG-0554.

3. Acceptance for meeting the relevant aspects of GDC 4 is based in part on Position C.5 of RG 1.13 “Spent Fuel Storage Facility Design Basis.”

9.1.5.4 Technical Evaluation

The staff reviewed Revision 3 of the US-APWR DCD for the OHLHS in accordance with NUREG-0800, “Standard Review Plan [SRP] for the Review of Safety Analysis Reports for Nuclear Power Plants,” Section 9.1.5, “Overhead Heavy Load Handling Systems,” Revision 1, issued March 2007.

A description of the OHLHS for the US-APWR is provided in DCD Tier 1, Section 2.7.6.5, and DCD Tier 2, Section 9.1.5. DCD Tier 1 Section 2.7.6.5.1 states that the function and purpose of the OHLHS is to move heavy loads, which for the US-APWR, is defined as any load greater than approximately 1111 Kg (2450 lbs).

DCD Tier 2, Section 9.1.5.2 states that the primary pieces of equipment used in the OHLHS are the main hoist of the spent fuel cask handling crane in the fuel handling area, the equipment hatch hoist in the PCCV, and the main and auxiliary hoist of the polar crane in the PCCV, each of which are single failure proof. Section 9.1.5.2 further states that, other than the single-failure-proof cranes, miscellaneous hoists and cranes with heavy load capacities are installed in safety-related areas of the US-APWR plant. However, the information provided in Section 9.1.5.2 of the DCD did not clearly identify the specific equipment that make up the OHLHS. To support the staff’s review of the OHLHS, it is necessary that all the heavy load handling equipment that is included as part of the OHLHS be clearly identified. Therefore, the staff requested in RAI 292-2232, Question 9.1.5.01 that the applicant clearly identify in its entirety the heavy load handling equipment, used as part of the OHLHS. In addition, the staff requested the applicant to clearly indicate in the DCD that the conditions of SRP Section 9.1.5.III.4 are met for each crane that could handle a critical load.

As defined in Section 9.1.5 of the DCD, a critical load handling evolution is defined as the handling of a heavy load where inadvertent operations or equipment malfunctions, separately or in combination, could:

a. Cause a significant release of radioactivity.
b. Cause a loss of margin to criticality.
c. Uncover irradiated fuel in the reactor vessel or SFP.
d. Damage equipment essential to achieve or maintain safe shutdown.

In its response, dated May 25, 2009 (MHI Ref: UAP-HF-09260), the applicant acknowledged the need for more detail on the cranes and hoists installed where load drops could result in damage to SSCs important-to-safety. Included in the DCD is Table 9.1.5-3, "Cranes and Hoists Installed Over Safe Shutdown Equipment," identifying cranes and hoists, including their respective seismic category and single-failure-proof status. Further review of the content of Table 9.1.5-3 and adherence to SRP Section 9.1.5.III.4 is discussed below.

9.1.5.4.1 System Design Considerations

A. GDC 1, "Quality Standards and Records"

The staff reviewed the OHLHS for compliance with the requirements of GDC 1, which requires that nuclear power plant 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. Compliance with the requirements of GDC 1 is based in part on complying with the guidance of NUREG-0554 for overhead handling systems and the guidance of ANSI N14.6 or ASME B30.9 for lifting devices.

DCD Tier 2, Section 9.1.5, states that the single-failure-proof cranes in OHLHS are designed in accordance with NUREG-0554, "Single-Failure-Proof Cranes for Nuclear Power Plants," using ASME NOG-1-2004, "Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)," to handle the maximum critical load based on the area in which it is operating. The primary OHLHS cranes that will handle heavy loads in the vicinity of spent fuel or safe shutdown equipment are identified as being the spent fuel cask handling crane, the equipment hatch hoist and the polar crane. The applicant states in Tier 2 Section 9.1.5.3 that all lifting devices used for the spent fuel cask, equipment hatch hoist and polar cranes are designed and fabricated in accordance with ANSI N14.6-1993, "Radioactive Materials-Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4500 kg) or More," with the exception of slings, which are supplied in accordance with ASME B30.9-2003, "Slings." The OHLHS components are subjected to various tests and inspections prior to being placed in service and are the subject of an ITAAC. The OHLHS is non-safety related. The applicant listed PCCV polar crane and spent fuel cask handling crane as Quality Group D, Seismic Category II and noted that these single-failure-proof cranes are designed in accordance with NUREG-0554 – "Single-Failure-Proof Crane," to maintain its position and hold titsheir loads during an SSE.

DCD, Tier 2, Table 1.9.3-1, “Conformance with Generic Issues” lists Crane Manufacturers Association of America (CMAA) 70 or 74 as applicable to cranes handling critical loads and makes repeated reference to ASME NOG-1 Type 1 cranes. However, in the design description of the OHLHS in DCD Section 9.1.5 there was no discussion on whether the OHLHS design conforms to the criteria specified in CMAA 70, 2000 and Chapter 2-1 of ANSI/ASME B30.2-2005 as recommended in SRP Section 9.1.5.III.3.F. In addition, ASME NOG-1 standard defines cranes classified into three types (I, II or III) depending upon crane location and usage of the crane at a nuclear facility. The DCD did not clearly identify the OHLHS cranes as ASME NOG-1 Type I, II or III. The staff requested in RAI 292-2232, Question 9.1.5.02, that the applicant clarify the above information and include the information in the DCD.

In its May 25, 2009, response to RAI 292-2232, Question 9.1.5-02, the applicant confirmed that the OHLHS cranes are designed to CMAA-70-2000 and ASME B30.2-2005, and specified Type I rating in accordance with the guidance in ASME NOG-1 for the main hoists of the spent fuel cask handling and polar cranes. In addition, as a result of RAI 616-4865, Question 9.1.5-18 and RAI 616-4865, Question 9.1.5-19 below, the equipment hatch hoist and the auxiliary hoist of the polar crane are also designed in accordance with NOG-1. The applicant also clarified that the suspension hoist (considered part of the LLHS) and the auxiliary hoist of the spent fuel cask handling crane will not handle critical loads and are not designed as single-failure-proof systems, but will meet the “electrical performance requirements” of Type II cranes in accordance with ASME NOG-1 Section 6320(c). The applicant proposed to incorporate these clarifications into Section 9.1.5.1 and add a reference to CMAA-70-2000 in Section 9.1.7. The applicant also proposed an addition to Tier 2 Section 9.1.5.3, specifying that administrative control procedures are required to be used to assure that the auxiliary hoists of the spent fuel cask handling crane does not handle heavy loads that could cause adverse consequences for nuclear safety. The applicant further proposed changes to New Generic Issue #186 in Table 1.9.3-1, under the “Status/Discussion” column, to provide for the correct designation of ASME NOG-1-2004 and CMAA-70-2000.

The staff verified that the DCD was revised to incorporate the changes detailed in the applicant’s response dated May 25, 2009, to RAI 292-2232, Question 9.1.5-02 into the DCD. The staff reviewed information provided and determined that the applicant used the appropriate codes in regards to the polar crane and spent fuel cask handling crane based on guidance provided in SRP Section 9.1.5. As a result, the DCD now clearly specifies the codes that apply, and the staff considers RAI 292-2232, Question 9.1.5-02, is closed. Also, additional review is performed below in response to RAI 616-4865, Question 9.1.5-18, and RAI 616-4865, Question 9.1.5-19, regarding the codes applied to the reclassified single failure proof equipment hatch hoist and the auxiliary hoist on the polar crane.

DCD Section 9.1.5.4 states that during fabrication, the quality assurance program (QAP) of the manufacturer satisfies the requirements of ASME NQA-1, “Quality Assurance Requirements for Nuclear Facility Applications.” The DCD also states that the manufacturer’s inspection and testing program and qualification of the assembled OHLHS will conform to ASME NOG-1-2004. Also prior to operation, the OHLHS is received, stored, and installed in accordance with ASME NOG-1-2004.

Periodic tests and inspections of the OHLHS are performed in accordance with Chapter 2-2 of ANSI/ASME B30.2-2005. The applicant stated in Section 9.1.5.5 that the OHLHS is equipped with mechanical and electrical limit devices to disengage power to the motors as the load hook approaches its travel limits or to prevent damage to other components when continued operation would potentially damage the OHLHS as required by NUREG-0554. Instrumentation is installed within the motor control circuits to detect and react to malfunctions such as excessive electric current, excessive motor temperature, over speed, overload, and over travel. Control devices are installed to absorb the kinetic energy of the rotating components and arrest the hoisting movement should the load line or one of the dual reeving systems fail, or should an overload and/or over speed condition occur. The control system is designed to include safety devices, which will assure the OHLHS returns to and/or maintains a secure holding position of critical loads in the event of a system fault. These safety devices are in addition to, and separate from, the control devices used for normal operation of the OHLHS. Emergency stop buttons are strategically placed at various locations to de-energize the OHLHS independent of the system controls.

Since the OHLHS complies with the guidance of NUREG-0554 and ASME NOG-1 for overhead handling systems and the guidance of ANSI N14.6 and ASME B30.9 for lifting devices, the staff finds the OHLHS complies with the requirement of GDC 1 as it relates to the systems and components important to safety being designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety function to be performed.

B. GDC 2, “Design Basis for Protection Against Natural Phenomena”

The staff reviewed the OHLHS for compliance with the requirements of GDC 2, with respect to its design for protection against the effects of natural phenomena. Compliance with the requirements of GDC 2 is based on adherence to Regulatory Position C.2 of RG 1.29, “Seismic Design Classification,” and Section 2.5, “Seismic Design,” of NUREG-0554.

Regulatory Position C.2 of RG 1.29 describes the guidance for Seismic Category II SSCs. This guidance states, in part, that Seismic Category II SSCs should be designed to preclude structural failure during a SSE to preclude interaction with safety related SSCs. Section 2.5 of NUREG-0554 specifies that single failure proof cranes should be designed to retain control of and hold the load during an SSE.

The spent fuel cask handling and polar cranes are single failure-proof cranes and are located in Seismic Category I building. Tier 2 Section 9.1.5.2.3 specifies that the polar crane has a seismic restraint system, which precludes derailment of either the hoist trolley or the main bridge box girders during a seismic event. As indicated by the applicant’s response to RAI 616-4865, Question 9.1.5-18, the equipment hatch hoist is also upgraded to single failure-proof and base-mounted to its support, which is designed to Seismic Category II requirements. The hoist supports are supported off the side of containment. In addition, the equipment hatch hoist is guided upward by guides to avoid any unanticipated horizontal movement.

The OHLHS uses single-failure-proof cranes; therefore, to comply with Section 2.5 of NUREG-0554 it is necessary that the design be able to retain control of and hold the load during an SSE. However, the DCD did not address the OHLHS ability to meet this requirement. Therefore, the staff asked the applicant in RAI 292-2232, Question 9.1.5-03, to explain how the OHLHS satisfies the criteria in NUREG-0554, Section 2.5 in terms of the ability of each of the OHLHS cranes to retain control of and hold loads during an SSE.

In its May 25, 2009, response to RAI 292-2232, Question 9.1.5-03, the applicant confirmed that the polar and spent fuel cask handling cranes main hoists are single-failure-proof cranes designed in accordance with NUREG-0554 and NOG-1. Therefore, these single-failure-proof cranes are designed to continue to hold their maximum load during an SSE. The applicant added clarifying language to DCD Tier 2 Section 9.1.5.2, along with a reference to this design requirement for addition to Tier 2 Table 3.2-2 Item 30. The staff finds this acceptable, since the added language provides clarity that the single-failure proof cranes are designed in accordance with NUREG-0554 to hold their load during SSE and RAI 292-2232, Question 9.1.5-03 is resolved. As discussed below in RAI 616-4865, Question 9.1.5-18 and RAI 616-4865, Question 9.1.5-19, the equipment hatch hoist is single failure proof and similarly designed to continue to hold its maximum load during an SSE.

As shown in Table 9.1.5-4, the cranes that are not single failure proof and installed over safe shutdown equipment are classified as Seismic Category II and, therefore, designed to continue to hold their maximum load during an SSE.

The cranes and hoist used in the OHLHS are not safety-related and, as indicated above, are designed to seismic Category II requirements, which is in accordance with the guidelines of Regulatory Position C.2 of RG 1.29. In addition, seismic design for single-failure-proof cranes is in accordance with Section 2.5 of NUREG-0554, which states that cranes should be designed to retain control of and hold the load, and the bridge and trolley should be designed to remain in place on their respective runways with wheels prevented from leaving the track during a seismic event.

Based on the above review, the staff concludes that the OHLHS is designed in accordance with Regulatory Position C.2 of RG 1.29, and NUREG-0554, Section 2.5, and meets the requirements of GDC 2 as they relate to the OHLHS design for protection against the effects of natural phenomena.

C. GDC 4, “Environmental and Dynamic Effects Design Bases”

The staff reviewed the OHLHS for compliance with the requirements of GDC 4 as it relates to the protection of fuel and safety-related equipment from the effects of internally generated missiles (dropped loads). A dropped heavy load in a critical area could cause a release of radioactive materials, a criticality accident, or inability to cool fuel within the reactor vessel or SFP or could prevent safe shutdown of the reactor. Position C.5 of RG 1.13 and Section 2.5 of NUREG-0554 provide guidance for meeting these requirements.

The safe handling of heavy loads by the OHLHS will be ensured by use of defense-in-depth measures consistent with the guidelines recommended in Section 5.1.1 of NUREG-0612. In the US-APWR design, the main hoists of the polar and spent fuel cask handling cranes are single failure proof. As defined in Section 9.1.5.1 of the DCD, the suspension hoist on the spent fuel cask handling crane and auxiliary hoists on these cranes were not to handle critical loads and were not designed as single-failure-proof. As discussed above, the staff submitted RAI 292-2232, Question 9.1.5.01 requesting the applicant to provide details (i.e., single failure-proof, loads, location, seismic category, etc.) for other OHLHS cranes located in other areas throughout the plant where any load drops could result in damage to SSCs important to safety. In its response to RAI 292-2232, Question 9.1.5-01, dated May 25, 2009 (MHI Ref: UAP-HF-09260), the applicant clarified that, except for the polar crane and spent fuel cask handling crane, the cranes and hoists listed in DCD Table 9.1.5-3 , entitled “Specification of the Equipment Hatch Hoist,” are not designed as single-failure-proof. DCD Section 9.1.5.3, contains the following justification for how the non-single-failure proof cranes and hoists in Table 9.1.5-3 are acceptable and satisfy the criteria of NUREG-0612 and SRP Section 9.1.5.III.4:

a. The non-single-failure proof cranes and hoists in Table 9.1.5-3 are not located over or adjacent to fuel assemblies. Therefore, a load handling incident involving the non-single-failure proof cranes and hoists would not impact fuel assemblies.

b. The non-single-failure proof cranes and hoists are located over safe shutdown equipment, but the plant configuration provides redundancy by separation of the components to assure that the effects of a single load drop from these cranes and hoists would not jeopardize the ability to achieve or maintain safe shutdown conditions. The hoists associated with the safety injection pumps, Core Spray (CS)/RHR pumps, Emergency Feedwater (EFW) pumps, Component Cooling Water (CCW) pumps, and CCW HXs are all located on the basement slab of the RB at floor elevation -26'-4", and each equipment train has its own room. Similarly, separation for other safe shutdown equipment serviced by non-single-failure proof cranes and hoists is achieved by walls, slabs, and/or adequate physical distance between adjacent equipment trains to assure that redundancy of safe shutdown functions is maintained in the case of a single load drop.

c. The non-single-failure proof cranes and hoists are dedicated to servicing particular pieces of safe shutdown equipment (such as pumps, valves, HXs, and chillers) or systems that will be out-of-service when the cranes and hoists are used for handling heavy loads over them. The use of these cranes and hoists is administratively controlled by load handling procedures to prevent overhead load handling that could cause unacceptable damage to the dedicated equipment or systems when in service.

As a result, the staff finds reasonable assurance that the load handling involving non-single-failure proof cranes and hoists listed in Table 9.1.5-3 will not jeopardize safe shutdown functions or cause a significant release of radioactivity, a criticality accident, or inability to cool fuel.

The staff reviewed the OHLHS DCD figures in Section 1.2 and confirmed that the non-single-failure proof cranes and hoists listed in Table 9.1.5-3 are not being located over or adjacent to fuel assemblies. In addition, the staff confirmed that the figures showed the non-single failure proof hoists are arranged so that load drop protection is achieved by walls, slabs, and/or adequate physical distance between adjacent equipment trains to assure that redundancy of safe shutdown functions is maintained.

As indicated above, the main hoists on the polar and spent fuel cask handling cranes are single failure proof. The staff finds, with the exception of the equipment hatch hoist and auxiliary hoists on the polar and cask handling cranes, the justifications for use of non-single-failure proof cranes listed in Table 9.1.5-3 provides reasonable assurance that load drop will not adversely affect safety. However, in response to RAI 292-2232, Question 9.1.5-01, Table 9.1.5-3 was revised to include the equipment hatch hoist as equipment that is located over Safe Shutdown Equipment. It was not clear to the staff what safe shutdown equipment was being referred to as located beneath the hatch hoist. In addition, the RAI response indicated that use of this hatch hoist is controlled using administrative procedures. Since the use of procedures is the only credited method to justify not handling loads when a postulated load drop could result in unacceptable consequences and the hatch hoist handles critical loads over SSEs, the staff asked the applicant in RAI 616-4865, Question 9.1.5-18 to justify how the guidance of SRP Section 9.1.5.III.4 is met.

In its response to RAI 616-4865, Question 9.1.5-18, dated September 22, 2010, the applicant confirmed that the equipment hatch hoist is located above SSCs required for shutdown and a load drop may cause adverse damage to SSCs required for safe shutdown or damage fuel. Therefore, the applicant upgraded the equipment hatch hoist to single-failure-proof crane. As indicated in Section 9.1.5.1 of the DCD, the equipment hatch hoist will be designed in accordance with the requirements of ASME NOG-1, Type I and guidance provided in NUREG-0554. In addition, the equipment classification will be equipment Class 5 and the crane will be base-mounted to supports that are mounted to the side of the containment, which are designed to seismic Category II requirements. In response to RAI 616-4865, Question 9.1.5-18, the DCD was updated in various sections to properly classify the equipment hatch hoist as single failure proof throughout the DCD. Based on the increase in safety with the upgrade of the hoist to single failure proof, the design is in accordance with SRP Section 9.1.5 and the possibility of a load drop is minimized. Although the RAI 616-4865, Question 9.1.5-18 response proposed an update of the DCD to properly classify the equipment hatch hoist, Revision 3 of the DCD did not incorporate Tier 1 information and ITAAC to reflect the single failure proof classification of the equipment hatch hoist. Therefore, the staff issued RAI 616-4865, Question 9.1.5-18, requesting that the applicant update the DCD Tier 1 information, including ITAAC, as committed in its response to RAI 616-4865, Question 9.1.5-18. RAI 616-4865, Question 9.1.5-18 is being tracked as **Open Item 9.1.5-01.**

US-APWR DCD Section 2.7.6.5.1 of Tier 1 provided the statement, “The safety analysis states that because the spent fuel cask handling crane is prohibited from traveling directly over the spent fuel, a spent fuel cask drop accident is an implausible event and is not required to be analyzed in the safety analysis.”

The staff asked the applicant in RAI 292-2232, Question 9.1.5-10 to address the following concerns with the Tier 1 statement above:

- The referenced “safety analysis” and details of the analysis were not provided in Tier 1 or Tier 2. The applicant was asked to provide analysis for review.

- Tier 2 takes credit for single-failure proof cranes to meet highly reliable handling system requirements of SRP Section 9.1.5.III.4 and NUREG-0612. However, the Tier 1 statement above seems to take credit for load path and mechanical stops to meet the SRP and NUREG-0612. The applicant was asked to revise Tier 1 and Tier 2 to be consistent.

- As indicated in Tier 1 statement above, spent fuel cask load drop analysis is not required since the crane is prohibited from traveling over spent fuel. Prohibiting travel over spent fuel addresses a cask drop accident over the spent fuel, but failed to address a potential cask drop accident that could cause damage to equipment essential to achieve or maintain safe shutdown. The applicant was asked to justify why a safety analysis is not needed for drop accident over equipment essential to achieve or maintain safe showdown.

In its response, dated May 25, 2009 (MHI Ref: UAP-HF-09260), the applicant clarified that there is no safety analysis because the main hooks of the PCCV polar crane and spent fuel cask handling cranes in question have a single-failure-proof design. The applicant removed the reference to a safety analysis from the Tier 1 Section 2.7.6.5.1 of the DCD and added language to clarify that only the main hooks of the cranes are single-failure proof. As a follow-up to the RAI response, the applicant was asked in RAI 563-4386, Question 9.1.5-16, to clarify which portions of the cranes (i.e. hooks, hoists, etc.) are designed with single failure proof features and update the DCD accordingly. To avoid confusion, the staff also asked for clarification with the use of the term "hooks" and "hoists".

In its response to RAI 563-4386, Question 9.1.5-16, dated June 15, 2010, the applicant clarified that the DCD will be revised to identify that the main hoisting systems are designed to conform to single failure proof criteria. The applicant further defined the hoisting systems as consisting of the reeving, hoisting mechanisms, and hooks used on a crane.

The staff finds that the RAI 563-4386, Question 9.1.5-16, response addressed the potential load drop from the auxiliary hoist on the spent fuel cask handling crane over spent fuel, based on its physical inability to travel over the SFP. However, the auxiliary hoist on the polar crane is capable of traveling over the spent fuel in the reactor vessel. The US-APWR polar crane contains two hoists (main and auxiliary crane) and only the main hoist was single failure proof. The auxiliary hoist on the polar crane was non-single failure proof and has a 45 metric tons (50 ton) capacity. Based on the RAI response, the polar crane auxiliary hoist does not contain any travel limitations to disallow travel over the reactor vessel, except by use of administrative procedures. As indicated in the DCD, the polar crane auxiliary hoist is more for reactor coolant pump motors and other similar sized equipment and is specified as not used to carry critical loads. However, the potential to carry a load over the reactor vessel would result in a critical load. In addition, the applicant appeared to take credit for the auxiliary hoist not carrying critical loads and controlling this by use of administrative procedures. This does not meet the guidance of SRP Section 9.1.5 (III.4) for non-single failure proof cranes. The staff asked the applicant in RAI 563-4386, Question 9.1.5-16, to justify how the use of administrative procedures will meet the guidance of SRP Section 9.1.5 (III.4) for the non-single failure proof auxiliary hoist on the polar crane.

In its response, dated September 22, 2010 (MHI Ref: UAP-HF-10255), the applicant stated that in order to meet guidance in SRP Section 9.1.5-III.4, the design of the polar crane auxiliary hoist will be upgraded to a single-failure proof hoist. As indicated in the DCD, the polar crane auxiliary hoist is upgraded to single failure proof and designed in accordance with the requirements of ASME NOG-1 and in accordance with the guidance provided in NUREG-0554. Based on the response to RAI 616-4865, Question 9.1.5-19, the staff verified that the DCD was updated to include changes to Table 3.2-2, Section 9.1.5 and Section 2.7.6.5.1 to properly reflect the main and auxiliary hoist of the polar crane being single failure proof design. The staff finds that the upgrade of the hoist results in increased safety to minimize the potential for a load drop. Therefore, RAI 616-4865, Question 9.1.5-18, is resolved.

DCD Tier 2, Section 9.1.5.1, states that the operation, testing, maintenance, and inspection of OHLHS are controlled through the use of safe load paths as defined in DCD Tier 2, Figures 9.1.5-1 through 9.1.5-4 and administrative procedures defined in Section 13.5.1 of the DCD. The load path of the spent fuel cask handling crane is limited to the locations shown in Figure 9.1.5-1 and as shown in the figure, the cask handling crane is prohibited from traveling directly over the SFP.

Section 9.1.5.1 of the DCD also states that the administrative control procedures govern the operation, testing, maintenance, and inspection of overhead heavy load handling system, and that the procedures follows the recommendations of Section 5.1.1 of NUREG-0612. The DCD also states that crane operator training and qualifications will be conducted in accordance with Chapter 2-3 of ANSI B30.2, and that inspection, testing and maintenance will be performed in accordance with Chapter 2-2 of ANSI B30.2 as recommended in Section 5.1.1 of NUREG-0612.

The applicant described in Section 9.1.5.1 that the OHLHS may be used to handle non-critical loads of greater weight than the maximum critical load. For those occasions, the maximum non-critical load is the design rated load. The design rated load does not have the safety factor limits of a single-failure-proof crane defined in NUREG-0554. The design rated load utilizes standard commercial practice safety factor limits. The overload sensing system is designed to be reset when switching the OHLHS between maximum critical load operations and design rate load operations. This resetting is performed remotely from the system controls and is governed by the OHLHS administrative control procedures. The applicant was asked to provide examples of non critical loads and explain the methodology to be used to determine that the loads are non critical in RAI 292-2232, Question 9.1.5-05.

In its RAI 292-2232, Question 9.1.5-05 response, dated May 25, 2009 (MHI Ref: UAP-HF-09260), the applicant defined the use of the OHLHS for handling non-critical loads of greater weight than the maximum critical load as the, “special lifting of heavy loads during construction or plant shutdown.”

The applicant further stated in RAI 292-2232, Question 9.1.5-05 response that prior to the lifting of non-critical loads after initial fuel loading, it would be demonstrated that the potential load drops due to inadvertent operations or equipment malfunctions, separately or in combination, would not jeopardize safe shutdown functions, cause a significant release of radioactivity, a criticality accident, or inability to cool fuel within the reactor vessel or SFP. The staff review finds the use of OHLHS to handle non-critical loads of greater weight than the maximum critical load is in accordance with Section 2.2 of NUREG-0554 and the concerns of RAI 292-2232, Question 9.1.5-05, are resolved. As a follow-up, the staff asked the applicant in RAI 563-4386, Question 9.1.5-15, to incorporate the details of the RAI 292-2232, Question 9.1.5-05 response into the DCD. Based on the RAI 563-4386, Question 9.1.5-15 response dated June 15, 2010, the DCD was updated to include the details of non-critical loads.

DCD Section 9.1.5.3 “Safety Evaluation,” states that slings for use with the single failure proof cranes (i.e. fuel cask handling and polar crane) are designed to ANSI/ASME B30.9. However, the applicant failed to state the other regulatory guidance specified in SRP Section 9.1.5.III.4.C.ii(2), which states that slings should be constructed of metallic material and be designed for twice the load or have dual/redundant configuration. The applicant was asked in RAI 292-2232, Question 9.1.5-06, to provide details on how the US-APWR will address the criteria for slings used on single failure proof OHLHS cranes.

Based on the response to RAI 292-2232, Question 9.1.5-06, dated May 25, 2009 (MHI Ref: UAP-HF-09260), the slings for use with single-failure-proof cranes conform to SRP Section 9.1.5.III.4.C.ii(2) regarding the use of metallic slings as specified in DCD Tier 2 Section 9.1.5.3. The staff finds this acceptable to address RAI 292-2232, Question 9.1.5-06, since the use of only metallic slings is in accordance with SRP Section 9.1.5.

In its review of the DCD, the staff noticed that the essential service water pump (ESWP) pit cranes listed in Table 3.2-2 were not discussed in DCD Section 9.1.5. Since the essential service water is a safety related system, the applicant was asked in RAI 292-2232, Question 9.1.5-01 to provide relevant design information for this crane. In the RAI response regarding the ESWP pit cranes associated with the ultimate heat sink related structures (UHSRS), the applicant stated that they are not included in the US-APWR standard plant design. Since these cranes may be temporary or mobile cranes, and their specific design and use is dependent on the configuration of the site-specific UHSRS, the applicant proposed to include these in COL Item 9.1(6) directing the COL applicant to include temporary cranes and hoists in the heavy load handling program.

Based on the above review of the OHLHS, the staff concludes that the design of the OHLHS adheres to the guidance given by Regulatory Position C.5 of RG 1.13 and Section 2.5 of NUREG-0554, since the OHLHS utilizes single-failure-proof cranes for handling critical loads, non-single failure proof OHLHS cranes are prevented by design from carrying heavy loads over the fuel, and the OHLHS satisfies the criteria of Section 5.1.1 of NUREG-0612. Therefore, the staff concludes that the OHLHS complies with the requirements of GDC 4, based on the OHLHS being designed to prevent internally generated missiles (i.e. load drops) that could prevent safe shutdown, cause an unacceptable release of radioactivity, result in a criticality accident, or cause the inability to cool the fuel in the reactor vessel or SFP.

D. GDC 5, “Sharing of Structures, Systems, and Components”

The OHLHS of the US-APWR is not shared between multiple units in accordance with DCD Tier 2, Section 9.1.5.1.4, which states, “SSCs important to safety are not shared with other reactor units”. Therefore, the staff concludes that GDC 5 is not applicable to the OHLHS.

9.1.5.4.2 Technical Specifications

US-APWR DCD lists no specific TS requirements associated with the OHLHS.

9.1.5.4.3 ITAAC

Tier 1 Section 2.7.6.5 of the US-APWR DCD provides a general overview of the system and includes the OHLHS ITAAC. The OHLHS ITAAC is designed to meet the requirements of 10 CFR 52.47(b)(1), to verify that the as-built system complies with the approved system design in the DCD. The OHLHS ITAAC is described in Tier 1 Table 2.7.6.5-1, “Overhead Heavy Load Handling System Inspections, Tests, Analyses, and Acceptance Criteria.”

One design criterion, among several design criteria for Tier 1 information, is that it should include features and functions that could have a significant effect on the safety of a nuclear plant or are important in preventing or mitigating accidents. A drop of the reactor vessel head assembly, a spent fuel cask, reactor coolant pump motors and other similar sized equipment could affect plant safety. Therefore, design features that reduce the risk and/or analyses that provide assurance of safety after a dropped load are important to safety. Section 9.1.5.1 of the US-APWR defines the polar and spent fuel cask handling cranes as single failure proof design. However, Revision 1 of the US-APWR DCD, Tier 1 Section 2.7.6.5 did not list “single failure proof” as certified design information and no ITAAC were included for either the polar crane or the spent fuel cask handling crane. The staff considers “single failure proof” design criteria for the OHLHS handling cranes as Tier 1 safety significant design criteria. Therefore, the staff requested the applicant in RAI 292-2232, Question 9.1.5-11, to justify why Tier 1 ITAAC did not include “single-failure proof” design criteria, which is considered safety significant for OHLHS cranes. In addition, the applicant was asked to address an ITAAC to verify the special lifting devices are designed in accordance with ANSI N14.6 and ANSI 30.9.

In its RAI 292-2232, Question 9.1.5-11 response, dated May 25, 2009 (MHI Ref: UAP-HF-09260), the applicant recognized the need to provide single-failure proof ITAAC and Tier 1 changes. The applicant further indicated that incorporation of the single-failure proof main hook design as a key feature of the OHLHS in Tier 1 Section 2.7.6.5.1 was addressed in its response to RAI 292-2232, Question 9.1.5-10 (see above). The applicant's RAI 292-2232, Question 9.1.5-11 response detailed the single failure proof ITAAC for the main hoists of the polar and spent fuel cask handling cranes and special lifting devices design. The applicant clarified that the RAI 292-2232, Question 9.1.5-11 response also included the changes made in response to RAI 14.3.7-31 into the Table 2.7.6.5-1 for completeness.

In regard to the special lifting devices, Table 2.7.6.5-1 was updated to include an ITAAC with the commitment that special lifting devices and slings used in conjunction with the PCCV polar crane main and auxiliary hoists and the spent fuel cask handling crane main hoist during critical load handling operations meet design requirements.

The applicant submitted Revision 2 of the DCD containing the corrections detailed in the applicant's response to RAI 292-2232, Question 9.1.5-11, with the modification that the provision to include special lifting device and sling requirements in DCD Tier 1 Table 2.7.6.5-1. The staff review of the RAI response and DCD Revision 2 found that the proposed ITAAC for declaration of single-failure proof appears too broad. The ITAAC should be used to verify certain key attributes of the single-failure proof crane using acceptance criteria from the licensing standard (i.e., NUREG-0554 or ASME NOG-1). The applicant was asked, in RAI 563-4386, Question 9.1.5-17, to re-evaluate the proposed single failure proof ITAAC with a more defined commitment and acceptance criteria. In addition, the applicant should provide a more defined ITAAC for critical special lifting devices.

The applicant addressed RAI 563-4386, Question 9.1.5-17, in its response dated June 15, 2010, by providing additional details of the basis for ITAAC and indicated that DCD Tier 1, Section 2.7.6.5.2, including Table 2.7.6.5.1, will be revised to provide better definition of features for the single-failure proof cranes ITAAC. These features include the items currently addressed in Table 2.7.6.5.1 as well as Non-Destructive Examination (NDE) of critical welds, static and dynamic load testing, and no-load testing per NUREG-0554 and ASME NOG-1. While the RAI 563-4386, Question 9.1.5-17, response provided ITAAC for the main hoists of the polar and auxiliary cranes, the response to RAI 616-4865, Questions 9.1.5-18 and 9.1.5-19 above provided a similar level of detail for ITAAC of the single-failure proof equipment hatch hoist and auxiliary hoist of the polar crane. As indicated above, RAI 616-4865, Question 9.1.5-18 response was not properly incorporated into Tier 1 and ITAAC regarding the single-failure proof design of the equipment hatch hoist and the staff issued RAI 616-4865, Question 9.1.5-18. Additional information is needed to close RAI 616-4865, Question 9.1.5-18. Based on the above, the staff finds the ITAAC to verify that all the hoists are single-failure proof components incomplete and RAI 616-4865, Question 9.1.5-18 remains open. **This is Open Item 9.1.5-01**.

Based on **Open Item 9.1.5-01**, the staff cannot conclude that the US-APWR OHLHS ITAAC meets 10 CFR 52.47(b)(1), which requires that a DC 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 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.

9.1.5.4.4 Initial Plant Test Program

The initial plant test program for the single-failure proof cranes are identified in DCD Tier 2, Section 14.2. As discussed in Section 14.2 of this SE, the staff reviewed the applicant's initial test program in accordance with the review guidance contained in Section 14.2, "Initial Plant

Test Program - Design Certification and New License Applicants," Revision 3 of the SRP, and RG 1.68 and RG 1.206. The staff's evaluation of the initial plant test program is documented in Section 14.2 of this SE.

Section 14.2.12.1.86, "Fuel Handling System Preoperational Test" contains the performance testing of the spent fuel cask handling building crane testing to demonstrate compliance with test requirements specified by NUREG-0554 (Reference 14.2-24), ASME NOG-1 (Reference 14.2-30) and NUREG-0612 (Reference 14.2-21) as applicable.

Section 14.2.12.1.105, "Vessel Servicing Preoperational test" contains the test program of the polar crane to demonstrate compliance with testing and inspection requirements specified by NUREG-0554 (Reference 14.2-24), ASME NOG-1 (Reference 14.2-30), and NUREG-0612 (Reference 14.2-21) as applicable.

Section 14.2.12.1.118, "Equipment Hatch Hoist Preoperational Test," contains the test program of the equipment hatch hoist to demonstrate compliance with testing and inspection requirements specified by NUREG-0554 (Reference 14.2-24), ASME NOG-1 (Reference 14.2-30), and NUREG-0612 (Reference 14.2-21) as applicable.

Since this testing program is consistent with the testing recommended in ASME NOG-1, NUREG-0554, and NUREG-0612, the staff finds the OHLHS initial plant testing acceptable.

9.1.5.4.5 COL Information

SRP Section 9.1.5 and NUREG-0612, provides guidance for applicants to include in a heavy load handling program for design, operation, testing, maintenance and inspection of heavy load handling systems. In addition, US-APWR DCD Table 1.9.3-1, "Conformance with Generic Issues (Page 1.9-365, Sheet 19 of 30)" provides a discussion of the minimum detail needed for heavy-load handling procedures. The applicant was asked, in RAI 292-2232, Question 9.1.5-12, to determine whether a COL information item should be developed to ensure that the COL applicant will provide such a heavy load handling program.

In its response, dated May 25, 2009 (MHI Ref: UAP-HF-09260), the applicant agreed to add a COL information item to DCD Tier 2 Section 9.1.6, as COL 9.1(6). COL 9.1(6) provides specific guidance directing a COL applicant to establish a heavy-load handling program, including associated procedural and administrative controls. The staff finds that COL 9.1(6) adequately defines the essential elements that the COL applicants will include in development of its heavy load handling program, in accordance with NUREG-0612 and RG 1.206. The staff verified that the DCD was modified to include the COL 9.1(6). Therefore, RAI 292-2232, Question 9.1.5-12 is considered closed.

However, Section C.I.9.1.5 of RG 1.206 contains specific guidance for the COL applicant to address in the heavy load handling program and the US-APWR COL 9.1(6) did not seem to include all the elements specified in RG 1.206. The response to RAI 9.1.5-01 specifically declared the ESWP pit cranes associated with the UHSRS to be outside the scope of the DCD. Thus, the staff issued RAI 563-4386, Question 9.1.5-14, requesting the applicant to address the guidance of the RG 1.206 item instructing the COL applicant to list the entire heavy load handling equipment outside the scope of the certified design.

In its response to RAI 563-4386, Question 9.1.5-14, dated June 15, 2010, the applicant proposed to revise DCD Section 9.1.6 to include all the load handling items from RG 1.206 C. I.

9.1.5. The staff reviewed COL Information Item 9.1(6) as listed in Tier 2 of the US-APWR DCD Revision 3, and found that the information from the response to RAI 563-4386, Question 9.1.5-14 had been incorporated. The COL item is acceptable because it contains the appropriate elements to ensure the COL applicant will describe the program and schedule for implementation of the program governing heavy load handling. Therefore, RAI 563-4386, Question 9.1.5-14 is considered to be closed.

9.1.5.5 Combined License Information Items

The following is a list of item numbers and descriptions from Table 1.8-2 of the US-APWR DCD, Revision 3. The table was augmented to include "action required by COL applicant/holder."

Table 9.1.5-1
US-APWR Combined License Information Items

Item No.	Description	**Section**
9.1-6	*To assure proper handling of heavy loads during the plant life, the COL Applicant is to establish a heavy load handling program, including associated procedural and administrative controls, that satisfies commitments made in Subsection 9.1.5 of the DCD, and that meets the guidance of ANSI/ASME B30.2, ANSI/ASME B30.9, ANSI N14.6, ASME NOG-1, CMAA specification 70-2000, NUREG-0554, NUREG-0612, and NUREG-0800, Section 9.1.5 and RG 1.206 C.I.9.1.5. During the operating life of the plant, it is anticipated that temporarily installed hoists and mobile cranes will also be used for plant maintenance. The heavy load handling program will include all cranes and hoists on site capable of handling heavy loads, including temporary cranes and hoists. The heavy load handling program will adopt a defense-in-depth strategy to enhance safety when handling heavy loads. For instance, the program will restrict lift heights to practical minimums and limit lifting activities as much as practical to plant modes in which load drops have the smallest potential for adverse consequences, particularly when critical loads are being handled. Further, prior to the lifting of heavy loads after initial fuel loading, the program will institute any additional reviews as necessary to assure that potential drops of these loads due to inadvertent operations or equipment malfunctions, separately or in combination, will not jeopardize safe shutdown functions, cause a significant release of radioactivity, a criticality accident, or inability to cool fuel within the reactor vessel or spent fuel pool.* *"The COL Applicant will prepare a non-critical heavy load procedure that includes sections, on the Design Bases, System Descriptions. Safety Evaluation. Inspection and Testing Requirements, and Instrumentation Requirements for the program. The heavy load program will include requirements for sufficient operator training, system design, load handling instructions. and equipment inspections. Safe load paths will be defined so that heavy loads avoid being moved over or near irradiated fuel or critical equipment. Mechanical stops or electrical interlocks to prevent movement of heavy loads near irradiated fuel or safe shutdown equipment may also be employed."*	

9.1.5.6 Conclusions

The overhead heavy load handling system includes all components and equipment for the handling of heavy loads at the plant site. After review of the applicant’s proposed design criteria and design bases for the OHLHS, the staff finds that the OHLHS design is in compliance with GDC 1, 2, and 4 and 10 CFR 52.47(b)(1). In addition, the staff concludes that GDC 5 is not applicable to the OHLHS of the US-APWR, as it is not shared between multiple nuclear power units. Upon closure of the Open Item 9.1.5-01 that is RAI 616-4865, Question 9.1.5-18, the staff can finalize that the applicant’s OHLHS design provided in the U.S. APWR DCD is in compliance with GDCs and the requirements of 10 CFR 52.47(b)(1) on ITAAC.

9.2.1 Essential Service Water

9.2.1.1 Introduction

The essential service water system (ESWS) provides cooling water to remove the heat from the CCWS HXs and the essential chiller units in the ECWS. The ESWS transfers the heat from these components to the ultimate heat sink (UHS). The CCWS, ECWS, and UHS are evaluated in this SE under Sections 9.2.2, 9.2.7, and 9.2.5 respectively.

The ESWS consists of four independent divisions with each division providing 50 percent of the cooling capacity required for its safety function. Each ESWS division takes suction from its associated UHSRS division and transfers the water through an underground pipe tunnel (ESWPT) into the RB and PS/B. The cooling water then returns to the UHSRS via the ESWPT. Each division is physically separated from the other division inside the RB and PS/B. The standard plant design includes only those portions of the ESWS inside the RB and PS/B and does not include the detailed ESWPT or UHSRS design. The standard plant design does confirm the requirement to have an ESWPT and UHSRS and provides conceptual design information (CDI) sufficient to identify all necessary interface requirements (refer to Section 9.2.5 for UHSRS). The standard plant design also includes certain ESWS functional requirements for structures and components that are contained in the ESWPT and UHSRS including:

- Emergency Service Water (ESW) pump.
- ESW pump discharge strainer.
- ESW pump discharge motor operated valve.
- ESW pump discharge check valve.
- Vacuum breaker installed upstream of the check valve.
- Instrumentations such as the pump discharge pressure sensor for confirmation of pump performance, the ESW header line pressure sensor and the pump discharge.
- Strainer differential pressure sensor.
- Associated isolation valves and piping.

The ESWS does not provide cooling to any non-safety loads. Each safety-related ESWS train is powered by a Class 1E electric bus with emergency power from its associated gas turbine generator (GTG).

9.2.1.2 Summary of Application

DCD Tier 1: The ESWS is addressed in Tier 1, Section 2.7.3.1, "Essential Service Water System." The functional arrangement of the ESWS is shown in DCD Tier 1, Figure 2.7.3.1-1, "Essential Service Water System." Design information is provided in DCD Tier 1, Table 2.7.3.1-1, "Essential Service Water System Location of Equipment and Piping," which provides physical locations and system equipment. Equipment characteristics and piping characteristics are provided in DCD Tier 1, Table 2.7.3.1-2, "Essential Service Water System Equipment Characteristics," and Table 2.7.3.1-3, "Essential Service Water System Piping Characteristics," respectively. Instrument, control, and electrical design information including power supplies, control, and display locations are identified in DCD Tier 1, Table 2.7.3.1-4, "Essential Service Water System Equipment Alarms, Displays, and Controls Functions." ESWS interface requirements are described in Section 3.2.3.

DCD Tier 2: The ESWS is also addressed by DCD Tier 2, Section 9.2.1 and Figure 9.2.1-1 (three sheets). Associated with ESWS, Tier 2 also includes Table 9.2.1-1 through Table 9.2.1-4.

ITAAC: ITAAC for the ESWS are included in DCD Tier 1, Table 2.7.3.1-5, "Essential Service Water System Inspections, Tests, Analyses, and Acceptance Criteria." Initial plant testing for the ESWS is described in DCD Tier 2, Section 14.2.12.1.34 "Essential Service Water System Preoperational Test." Discussion of the ITAAC and the pre-operational test are provided in Section 9.2.1.4, "Technical Evaluation," of this SE.

TS: TS for the ESWS are provided by DCD Tier 2, Chapter 16 TS 3.7.8. For discussion of this TS as it relates to the ESWS, refer to the Section 9.2.1.4 of this SE.

9.2.1.3 Regulatory Bases

The relevant requirements of the NRC regulations for this area of review, and the associated acceptance criteria, are given in NUREG-0800, Section 9.2.1, "Station Service Water System," Revision 5, issued March 2007, and are summarized below. Review interfaces with other SRP sections also can be found in NUREG-0800, Section 9.2.1.

1. GDC 2, "Design Basis for Protection Against Natural Phenomena," as it relates to the capabilities of structures housing the system and the system itself having the capability to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of safety-related functions.

2. GDC 4, "Environmental and Dynamic Effects Design Bases," as it relates to effects of missiles inside and outside containment, effects of pipe whip, jets, environmental conditions from high- and moderate-energy line-breaks, and dynamic effects of flow instabilities and attendant loads (e.g., water-hammer) during normal plant operation, as well as upset or accident conditions.

3. GDC 5, “Sharing of Structures, Systems, and Components,” insofar as it requires that SSCs important to safety not be shared among nuclear power units unless it can be shown that sharing will not significantly impair their ability to perform their safety functions.

4. GDC 44, “Cooling Water,” as it relates to the capability to transfer heat from systems, SSCs important to safety to an UHS during both normal and accident conditions, with suitable redundancy, assuming a single active component failure coincident with either the LOOP or loss of onsite power.

5. GDC 45, “Inspection of Cooling Water System,” as it relates to design provisions for in-service inspection of safety-related components and equipment.

6. GDC 46, “Testing of Cooling Water System,” as it relates to design provisions for pressure and operational functional testing of cooling water systems and components in regard to

   - Structural integrity and system leak-tightness of its components.
   - Operability and adequate performance of active system components.
   - Capability of the integrated system to perform credited functions during normal, shutdown, and accident conditions.

7. CFR 52.47, “Contents of applications; technical information,” Item (b)(1), which requires that a DC 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 facility that incorporates the DC has been constructed and will be operated in accordance with the DC, the provisions of the Atomic Energy Act of 1954, and NRC regulations.

8. CFR 20.1406, “Minimization of Contamination,” as it relates to the standard plant DCs and how the design and procedures for operation will minimize contamination of the facility and the environment, facilitate eventual decommissioning and minimize to the extent practicable, the generation of radioactive waste.

Acceptance criteria adequate to meet the above requirements include:

- RG 1.29, “Seismic Design Classification,” issued March 2007, (Seismic Design Criteria), Regulatory Position C.1 for safety-related and Regulatory Position C.2 for nonsafety-related portions of the ESWS.

9.2.1.4 Technical Evaluation

The staff’s evaluation of the ESWS is based upon the information provided by the applicant in an October 14, 2011 letter, “Markup for US-APWR DCD Section 9.2,” which transmitted DCD Tier 2, Section 9.2.1, Interim Revision 4. This letter also provided DCD markups for other Tier 1 and DCD Tier 2, sections applicable to the review of DCD Tier 2, Section 9.2.1.

For ESWS, the staff requested that the applicant respond to questions in fifty-nine RAIs that were based on the information in DCD Revisions 0, 1, 2 and 3 that described the design, operation, and testing of the ESWS. The applicant answered these questions in numerous responses that included DCD markups which the staff reviewed and finds acceptable. In an October 14, 2011, letter, the applicant provided the DCD Interim Revision 4 markup for the applicable DCD sections. The staff reviewed the response and confirmed that the DCD Interim Revision 4 markup, dated October 14, 2011, includes all of the relevant ESWS RAI responses. In this SE, the staff is not describing each staff RAI and applicant response. The staff's technical evaluation is based on review of the DCD Interim Revision 4 markup for the applicable sections. In some cases, RAI responses are discussed where clarifying information was not described in the DCD markup. To ensure that the DCD Interim Revision 4 markup information gets incorporated in the latest revision of the DCD, **the October 14, 2011 letter is being tracked as a confirmatory item.**

9.2.1.4.1 General Design Criteria

GDC 2

DCD Tier 2, Section 3.2, "Classification of Structures, Systems and Components," identifies the SSCs based on safety importance and other considerations. Table 3.2-2, "Classification of Mechanical and Fluid Systems, Components, and Equipment," provides the component safety classification, seismic classification, quality group classification, comment commercial codes and locations for the SSCs.

Information that addresses GDC 2 will be considered acceptable if the requirements of RG 1.29 (Seismic Design Criteria) Position C.1 for safety-related and Position C.2 for non-safety related portions of the ESWS are met.

The staff finds that the safety classification, quality group, seismic category and location for the ESWS components are properly designated. All safety-related portions of the ESWS are located inside seismic Category I, tornado-, missile-, and flood-protected buildings, which for this system are the RB and PS/B. Within both of these protected structures, the four ESWS divisions are completely physically separated from one another. The Essential Service Water Pipe Tunnel (ESWPT) and UHSRS detailed structural design is outside the scope of the standard plant design and will be determined by COL applicants (COL Information Item 9.2(4) and COL Information Item 9.2(5)). However, the ESWS piping and components (e.g. the ESW pump) located inside these structures must also meet GDC 2 requirements and will be evaluated during site specific reviews when a more detailed design is provided. The ESWS is also designed to ensure that failure of any non-safety related portions of the system do not compromise any safety function of the ESWS. As the ESWS does not cool any non-safety related loads, there are no boundary valves between safety and non-safety related portions to evaluate. COL Information Item 9.2(7) requires review for any future non-safety boundary valves.

Related to COL Item 9.2(7), Comanche Peak, the applicant indicated in a January, 23, 2012, call with the NRC that safety-related to nonsafety-related boundary valve, AOV-577 (shown on Figure 9.2.1-1, Sheet 1) has four different power supplies. The different power supplies are not specifically described in the DCD. The COL applicant stated that this item should be resolved in the DCD and not under COL Item 9.2(7); therefore, this is an open item. In addition, AOV-577 logic states that this valve closes on ESWS pump stop. AOV 577 logic to close should be clarified and the FMEA revised, Table 9.2.1-2. This Open Item will also address:

- FMEA may be needed for AOV 577 not going full open (is there a safety feature for this valve to remain open). If the valve fails closed during power operations, the UHS basin chemistry may not be able to be maintained

- FMEA may be needed for VLV-544A/B/C/D (blowdown bypass) being open with single failure of AOV 577 not fully closing (which might occur if there were a bent valve stem).

- Not all boundary valves are listed in the DCD FMEA that appear in the Comanche Peak COL FMEA.

The staff's evaluations of protection provided for the SSCs which are important to safety are included in the following sections of this SE.

- Section 3.3 of this SE addresses the staff's evaluation of protection against natural phenomena such as wind and tornado effects.

- Section 3.4.1 of this SE addresses the staff's evaluation of flood protection provided for the SSCs which are important to safety.

- Section 3.5.1.4 of this SE addresses the staff's evaluation of protection provided for the SSCs which are important to safety from missiles generated by natural phenomena.

- Section 3.5.2 of this SE addresses the staff's evaluation of protection provided for the SSCs which are important to safety from externally generated missiles.

- Section 3.12.3 of this SE addresses the staff's evaluation of protection provided to prevent non-seismic lines and equipment from having adverse interactions with the SSCs which are important to safety. DCD Tier 2, Section 3.12.3.7, "Non-seismic/Seismic Interaction (II/I)," identifies acceptable methods to address the potential for interaction between seismic qualified and non-seismic qualified portions of the ESWS that are routed through the same areas, such as the RB.

Open item related to boundary valve AOV-577 needs to be resolved; therefore, the staff cannot find that GDC 2 requirements have been satisfied.

GDC 4

The staff's review of the ESWS is to determine if the design complies with the relevant requirements of GDC 4. As stated in Tier 2, DCD Section 9.2.1.1.1, the ESWS is protected against adverse environmental, operating, and accident conditions that can occur, such as flooding, high energy line break (HELB), thermal over-pressurization, and water hammer. Section 3.6.1 of this SE addresses the staff's evaluation of the design of structures, shields, and barriers necessary for SSCs to be protected against dynamic effects of high- and moderate-energy line breaks. Based on the staff's evaluation discussed in Section 3.6.1 of this SE, the staff finds that the ESWS is protected against the effects of, and is compatible with, the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents. Section 3.5.1 evaluates the effects of internal missiles generated inside and outside the containment regarding the SSCs which are important to safety. Based on the staff's evaluation discussed in Section 3.5.1 of this SE, the staff finds that the ESWS is protected against internally generated missiles.

In addition, the staff's review of the ESWS description was to confirm that the applicant has adequately addressed water hammer considerations. Two of the four safety-related trains are normally in operation with at least one of the remaining two trains in standby. During a plant shutdown or startup, three or four ESWS trains may be in operation at the same time as described in Tier 2, DCD Table 9.2.1-3. For water hammer concerns when a new train is started manually or automatically, the COL Applicant is to determine the piping layout of the UHS to maintain the ESWS/UHS pressure above saturation pressure for all operating modes (COL Information Item 9.2(31)). This prevents potential void formation during pump stoppage and during pump operation due to additional dynamic head. To preclude water hammer on ESWS pump re-start, the Motor Operated Valve (MOV) at each pump discharge is interlocked to close when the pump is not running or is tripped. This interlock prevents the pump from starting if the valve is not closed except during emergency situations such as an accident or LOOP events when the signal is overridden. Upon receiving a pump actuation signal (manual start or automatic start), the MOV starts to gradually open to preclude water hammer. An automatic vent valve is also installed to sweep out air introduced into the piping system by the vacuum breakers that are installed to prevent water hammer. The COL Applicant is to develop system filling, venting, keeping the system full, and operational procedures to minimize the potential for water hammer; to analyze the system for water hammer impact; to design the piping system to withstand the potential water hammer forces; and to analyze inadvertent water hammer events, in accordance with NUREG-0927, "Evaluation of Water Hammer Occurrence in Nuclear Power Plants," (COL Information Item 9.2(25)). In addition, the COL Applicant is to develop a milestone schedule for implementation of the operating and maintenance procedures for water hammer prevention (COL Information Item 9.2(27)) and provide a void detection system with alarms to detect system voiding (COL Information Item 9.2(32)).

SRP 9.2.1 guidance states that the design provisions presented in NRC Generic Letter (GL) 96-06, "Assurance of Equipment Operability and Containment Integrity during Design - Bases Accident Conditions and Water Hammer," are appropriately addressed. The staff finds that for the US-APWR ESWS design, there is no ESWS flow to the containment air coolers since the containment air cooler are normally supplied by the Non-ECWS which is discussed in Section 9.2.7 of this SE. Therefore, GL 96-06 Items 1 and 2 discussed above, which specifically address the containment air coolers, do not apply to the US-APWR design.

The ESWS is designed for operation at low water temperature of 32 °F during all modes of plant operation. The COL Applicant is to provide protection for the site specific safety-related portions of the ESWS (including those portions of the system in the ESWPT and UHSRS) against adverse environmental, operating, and accident conditions that can occur such as countermeasures to freezing by safety-related heat tracing, low temperature operation, and thermal overpressurization (COL Information Item 9.2(2)). Temperature in the RB and PS/B is maintained through ventilation and therefore heat tracing is not required for ESWS portions located within those buildings. For SSCs outside the scope of the certified design building such as the branch piping to the pump discharge pressure sensor, the possibility for freezing depends on the location, which is determined by the COL Applicant and will be evaluated during site specific reviews.

Accordingly, based on the preceding discussion, the staff concludes that the ESWS meets the requirements of GDC 4, including GL 96-06 and water hammer consideration for the ESWS.

GDC 5

The US-APWR standard plant design is a single-unit station and, consequently, there are no shared safety-related SSCs between different units. Therefore, the provisions of GDC 5 are not applicable to the US-APWR standard plant design.

GDC 44

The ESWS must be capable of removing heat from SSCs important to safety during normal operating and accident conditions over the life of the plant in accordance with GDC 44. The following ESWS design considerations were evaluated to determine if the ESWS is capable of performing its functions in accordance with this requirement.

DCD Tier 2, Figure 9.2.1-1, "ESWS Piping and Instrumentation Diagram" (Sheets 1 through 3), Table 9.2.1-1 "ESWS Component Design Data," Table 9.2.1-3 "ESWS Heat Loads," and Table 9.2.1-4 "ESWS Flow Balance," provide detailed system parameters for all six ESWS operating modes, which include; startup, power operations, refueling, cooldown, accident, and safe shutdown. The figure includes flow diagrams identifying system locations and the tables provide detailed pressure, temperature, heat removal, and flow-rate conditions for each of these six operating modes.

The staff finds this figure and tables acceptable since the applicant provided detailed pressure, temperature, heat removal, and flowrate conditions for each ESWS mode of operation. The design ESWS flowrate of 13,000 gallons per minute (gpm) at a design temperature of 95 ºF is acceptable because it provides a 7.7 percent margin to the worst case cooling flow requirements (12,043 gpm) as shown in Table 9.2.1-4. In addition, having four independent 50 percent capacity ESWS trains allows for even more added margin during accidents where only a single failure occurs and one train is lost. DCD Tier 2, Table 9.2.1-2 provides ESWS failure modes and effects for various single failures. All four trains receive an automatic start signal in the event of a LOOP or LOCA. DCD Tier 2, Chapter 9.2.1.2.3.1, states the 95 ºF temperature is deemed conservative and supports safely bringing the reactor coolant temperature from 350 °F to 200 °F, 36 hours after reactor shutdown via four operating ESWS and CCWS trains. Failure of one train will not prevent the ESWS from achieving cold shutdown conditions.

The ESW pump operation, ESW header pressure signals, and component cooling water pump operation are interlocked to enable automatic start and stop functions of the pumps. A low ESW header pressure signal due to failure or tripping of an operating ESWP is alarmed in the MCR. When the low ESW header pressure alarm is annunciated, the standby ESWP and the standby CCWP of the same train designation start automatically as described in DCD Tier 2, Chapter 9.2.1.2.3.1. In the same manner, a low CCW supply header pressure signal accompanied by a start signal from the CCW pump in the same train will automatically start the corresponding ESW pump and the associated ESW pump discharge valve will automatically slowly open.

DCD Tier 2, Table 9.2.1-1, entitled "Essential Service Water System Component Design Data," also describes all the safety related ESWS components and their 1E electrical division. The staff finds this table acceptable since it clearly identifies the ESWS pump, pump discharge MOV, and pump outlet strainer (to include power to the rotating brushes motor and associated valves needed for backwash function) as being powered from its respective Class 1E power source and associated GTG.

Each pump is designed to provide 13,000 gpm flow at the required total dynamic head (TDH).

As stated in DCD Tier 2, 9.2.1.2.2.1, the required pressure drop across the ESWS components and piping is approximately 100 feet. The COL Applicant is to provide the evaluation of the ESWS at the lowest probable UHS water level (COL Information Item 9.2(1)). The COL Applicant is to determine the required ESWP TDH by adding pressure drop across the site-specific components and piping and maximum static lift to this pressure drop. The COL Applicant is to provide the site specific data for the ESWPs and to assure that the selected ESWP will require less Net Positive Suction Head (NPSH) than the minimum available NPSH under all operating conditions. The COL Applicant is to assure that the sum of the shut-off head of the selected ESW pumps and the static head will not result in exceeding the ESWS design pressure. The COL Applicant is also responsible for the testing to evaluate the potential for vortex formation based on the most limiting assumptions that apply (e.g., temperature, flow rate, operation of other pumps for vortex evaluation). All of these NPSH concerns are outlined in COL Information Item 9.2(6). The staff finds this acceptable as site-specific details need to be developed in future COL applications (COLAs) to evaluate ESWS pump NPSH margins.

To avoid concerns with potential downstream pipe-wall thinning, butterfly valves provided in the ESWS piping are not used for excessive throttling of the water flow. The valves are sized such that they are near the full open position during the various modes of plant operation. Valve opening margins are included to ensure that the design flow is met during all plant operating modes. Restriction orifices are provided downstream of the HXs as required for flow balancing. Orifices having adequate differential pressures are installed downstream of the HXs to prevent excess throttling of the butterfly flow control valves.

Two 100 percent capacity safety-related parallel strainers powered from Class 1E power sources are located in each ESWP discharge line to prevent the CCW HX from clogging. The COL Applicant should perform periodic inspection, monitoring, maintenance, performance and functional testing (including the heat transfer capability of the CCW HXs consistent with GL 89-13) to minimize the effect of potential CCW HX fouling (COL Information Item 9.2.1(30)). These activities will ensure that the actual fouling factor will not exceed the design fouling factor for at least the duration required for UHS capacity of 30 days or minimum of 36 days for a cooling pond. The strainers are the automatic self-cleaning type during normal operation; each has a backwash line with an isolation valve of MOV-573 or MOV-574 as shown in Figure 9.2.1-1 with its valve ID marking. The COL Applicant is to determine the backwash line discharge location in accordance with the type of UHS used (COL Information Item 9.2(33)). The backwash line valves, are powered by a Class 1E DC source so that they will be operable during LOOP. The strainers have exhaust valves, which are part of the strainers; the valve symbol is shown but a unique valve identification (ID) is not identified in Figure 9.2.1-1. Also, the strainers have manual isolation valves, VLV-506 and VLV-507, on ESW inlet piping and have manual isolation valves, VLV-508 and VLV-509, on ESW outlet piping respectively as shown in Figure 9.2.1-1 with its valve ID marking. These valves allow a strainer to be taken out of service. An automatic vent valve is also installed to sweep out air introduced into the piping system by the vacuum breakers that are installed to prevent water hammer. Inside the strainer there is a cylindrical screen with a rotating brush; the brush sweeps the inner surface of the cylindrical screen when the strainer receives start signal. The strainers, including its associated components such as exhaust valve or rotating brush motor, are powered from the associated Class 1E source.

Strainer operating modes are Non-Backwash Operating, Backwash Operating or Out-of-Service. The strainer is available when in either of the two “operating” modes. The only difference in “Backwash Operating” mode is that the strainer is actively backwashing at that time. As soon as the backwash stops (the discharge and exhaust valves close and the brushes stop rotating), the strainer returns to “Non-backwash Operating” mode unless it is manually placed out-of-service for maintenance by closing the manual isolation valves. DCD Tier 2 Chapter 9.2.1.2.2.2, describes in detail the various valve arrangements for the operating modes.

During LOOP and LOCA events, the backwash discharge valves (MOV-573 and MOV-574) automatically receive a signal to open. To complete the initiation of a backwash, the MCR operator must also provide a start signal to a non-backwash operating strainer using the Visual Display Unit (VDU) switch. This switch will open the associated strainer exhaust valve (which is in series with the backwash discharge valve) and start the rotating brush motor. This manual operator action finalizes backwash initiation to the strainer. The operator initiates a backwash if low ESWS flow to the CCWS HX alarms which is a safety-related instrument, and an indication of filter fouling alarms. Should an ESWS pump trip post-accident, the associated backwash isolation valve, MOV-573 or MOV-574 and the strainer integral exhaust valve are interlocked to close at a pump stop signal from Protection and Safety Monitoring System (PSMS) to prevent water drainage that could lead to water hammer upon subsequent restart. This closure signal overrides all safety and non-safety backwash operating signals. The staff finds this acceptable because if the ESWS train is not running, then backwash for that train is not needed. Each train is provided with a second 100 percent strainer that can be manually placed in service should a strainer fail. This gives each division added margin and flexibility.

The strainers have a 3 millimeter (mm) mesh which is considered to effectively remove debris from the system that could clog the CCW plate HXs with flow passages approximately 3 to 6 mm in diameter. Since the essential chiller units, being shell and tube type HXs, have a much larger flow path than the CCW HXs, the staff finds that no strainer for additional filtering is necessary since the mesh size is maintained smaller than the smallest flow path (in conjunction with other fouling controls outlined below).

The COL Applicant is to specify appropriate sizes of piping and pipe fittings such as restriction orifices to prevent potential plugging due to debris buildup, and develop maintenance and test procedures to monitor debris build up and flush out debris (COL Information Item 9.2(26)). The COL Applicant is to evaluate the capability of the ESWS to provide measures to prevent long-term corrosion and organic fouling that may degrade its performance, per GL 89-13 (COL Information Item 9.2(30)). The COL Applicant is to specify the following ESWS chemistry requirements (COL Information Item 9.2(8)):

- A chemical injection system to provide non-corrosive, non-scale forming conditions to limit biological film formation.

- Type of biocide, algaecide, pH adjuster, corrosion inhibitor, scale inhibitor and silt dispersant based on the site conditions.

The effect of long-term corrosion of the piping is mitigated by adding a corrosion inhibitor.

The ESW is periodically sampled and chemicals are added, as required, during power operation.

Accordingly, based on the preceding discussion, the staff concludes that the ESWS meets the requirements of GDC 44, which includes the requirements for the transfer of heat from the SSCs important to safety to a heat sink during both normal and accident conditions assuming a single failure. The staff also concludes that the appropriate ESWS pump NPSH, fouling, and chemistry controls to ensure sufficient cooling during accident conditions will be evaluated pending completion of identified COL items by future COL Applicants.

<u>GDC 45</u>

DCD Tier 2 Section 9.2.1.1, states that the ESWS is designed to permit periodic inservice testing and inspection of components to assure system integrity and capability in accordance with GDC 45 and ASME Code Section XI. The COL Applicant shall conduct periodic inspection, monitoring, maintenance, performance and functional testing of the ESWS and UHS piping and components, including the heat transfer capability of the CCW HXs and essential chiller units, consistent with GL 89-13 and GL 89-13 Supplement 1 (COL Information Item 9.2(30)). In addition, periodic inspection, monitoring and maintenance will ensure that the actual fouling is within design fouling factor margins to accommodate heat transfer for a minimum of the UHS design of 30 days or 36 days for a cooling pond.

Piping is arranged to permit access for inspection. The ESWP tunnel, including the ESW piping from this tunnel to the ESW pump intake and discharge structures and the UHS, is site specific but the existence and function of which are required in the standard design. Access manholes will be provided as required for periodic inspection. The piping will be inspected per ASME Section XI, article IWA 5244 requirements. Inservice inspection and testing of piping is performed in accordance with the requirements of ASME Section XI, as discussed in Section 6.6.

The staff finds sufficient provisions have been established to support a conclusion that reasonable assurance of compliance with GDC 45 exists.

<u>GDC 46</u>

DCD Tier 2 Section 9.2.1.1, states that the ESWS is designed to permit appropriate pressure and functional testing to assure the structural and leak-tight integrity of components, operability and the performance of the active components of the system, and system operability during reactor shutdown, LOCAs, including operation of applicable portions of the protection system and the transfer between normal and emergency power sources per GDC 46.

Inservice testing of active pumps and valves is performed to assure operational readiness, as described in Subsection 3.9.6. Acceptance criteria for the monitored parameters are established to allow for pump degradation and to maintain acceptable pump performance for all modes of plant operation. Periodic performance verification of the ESWS components, including the HX(s) cooled by the ESWS, is performed to detect performance degradation due to fouling. The HXs are monitored per test program developed in accordance with the requirements of GL 89-13. Acceptance criteria for performance verification are established to allow for degradation and maintain acceptable HX performance for all modes of plant operation.

Normally, a minimum of two trains of ESWS operate continuously in all plant operating modes. Operation of the pumps is rotated in service on a scheduled basis to obtain even wear. The COL Applicant is to develop operating procedures to periodically alternate the operation of the trains to ensure performance of all trains is regularly monitored (COL Information Item 9.2(30)). The system is located in accessible areas to permit in-service inspection as required.

The staff finds sufficient provisions have been established to support a conclusion that reasonable assurance of compliance with GDC 46 exists.

<u>10 CFR 20.1406 “Minimization of Contamination”</u>

10 CFR 20.1406 requires, in part, that applicants for standard plant DCs describe how the facility design and procedures for operation will minimize, to the extent practicable, contamination of the facility and the environment, as well as the generation of radioactive waste.

The CCWS is an intermediary closed loop system between the ESWS and potentially radioactive fluid. If, however, radioactive leakage does occur into the CCWS, radiation monitors will alarm in the MCR to enable immediate stoppage of the CCW pump and isolation of the leaking train. The leaking train is ultimately placed out of service to treat this problem. Therefore, prior to occurrence of radioactive leakage from the CCWS into the ESWS, isolation of the affected CCWS train should have taken place.

As added protection, DCD Tier 2, Section 9.2.1.5.6, states that radiation monitors are located downstream of the CCW HX and the signal is indicated locally and in the MCR. When the radiation level exceeds the setpoint, a separate high radiation ESWS alarm is transmitted both locally and to the MCR. The operator manually isolates the contaminated ESWS train and corresponding CCW train (if not already done) by stopping the ESWS and CCW pumps, and thus taking the contaminated CCW HX out of service. Standby CCWS and ESWS trains are placed in service. The manual isolation valves placed on each side of the CCW HX will also be closed to ensure that the radioactive leakage is not circulated in the ESW and eventually in the UHS. A second valve, which acts as a control valve, downstream of the CCW downstream isolation valve can also be closed to further isolate the train.

The staff concludes that there are sufficient radiation monitors and controls in place to isolate any radioactive leakage prior to finding a direct path for release into the environment via the ESWS/UHS. There are provisions for collection of samples, which are routinely taken by the operators and tested for radioactivity. In addition, ESWS radiation monitors are provided to alert the operators in case of a leak, thereby providing the opportunity for location and isolation of the faulted equipment. Since the probability of contamination in ESWS is very low and the isolation valves are rapidly closed when the in-leakage occurs, potential contamination of the ESWS is minimal.

The staff finds sufficient provisions have been established to support a conclusion that reasonable assurance of compliance with 10 CFR 20.1406.

9.2.1.4.2 Technical Specifications

DCD Tier 2 Chapter 16, TS 3.7.8, “Essential Service Water System,” provides LCOs and SR for the ESWS. TS 3.7.8 requires three of four ESWS trains to be operable in Modes 1, 2, 3 and 4. There is a 72 hour LCO entry if fewer than three ESWS trains are operable.

The staff has evaluated the US-APWR non-standard TS for ESWS (TS 3.7.8), which include the ESWS system SRs and finds the TS for ESWS have been adequately addressed and finds them acceptable.

Chapter 16 of this SE also addresses the staff's evaluation of the ESWS to assure that the proposed LCOs and associated Bases adequately address and reflect system-specific design considerations as described in Section 9.2.1.

9.2.1.4.3 Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC)

DCD Tier 1 Section 2.7.3.1, "Essential Service Water System," provides US-APWR DC information and ITAAC for the ESWS. Tier 1 information for balance-of-plant SSCs is evaluated in Section 14.3.7 of this SE, and evaluation of the Tier 1 information in this section is an extension of the evaluation provided in Section 14.3.7 of this SE. This evaluation pertains to plant systems aspects of the proposed Tier 1 information for ESWS.

Important aspects of the ESWS design include significant safety-related functions. Each division provides cooling water for a CCWS HX and ECWS chiller. Controls are provided to the MCR to open and close safety-related backwash isolation valves and start and stop ESWS pumps. All automatic safety actions are tested. All safety-related alarms and displays are tested. All safety-related functions of the ESWS pump outlet strainers are tested.

The staff reviewed the descriptive information, safety-related functions, arrangement, mechanical, instrumentation and controls (I&C) and electric power design features, environmental qualification, as well as system and equipment performance requirements provided in DCD Tier 1, Section 2.7.3.1, to confirm completeness and consistency with the plant design basis as described in DCD Tier 2, Section 9.2.1. The staff also reviewed DCD Tier 1, Table 2.7.3.1-1, Table 2.7.3.1-2, Table 2.7.3.1-3, Table 2.7.3.1-4, Table 2.7.3.1-5 and Figure 2.7.3.1-1.

Other important acceptance criteria related to the ESWS include functional arrangements, physical separation, ASME Code Data reports, ASME welding, ASME pressure testing, seismic classifications, equipment qualification for harsh environment, 1E power, and electrical separation.

DCD Tier 1 Section 3.2.3, identifies the interface requirements for the ESWS. Each of these interface requirements will require a site-specific ITAAC in future COLAs. The design details of the portions of the ESWS inside the ESWP tunnel and UHSRS were CDI. The staff finds that the CDI and interface requirements provided are sufficient to meet 10 CFR 52.47(a)(24) and (25).

The staff finds that all the necessary ESWS equipment has been adequately identified in the applicable tables. The staff concludes that if the ITAACs for ESWS are inspectable and are performed and the acceptance criteria met, there is reasonable assurance that a plant that incorporates the DC has been constructed and will be operated in conformity with the DC, provision of the Atomic Energy Act of 1954, and NRC regulations which include 10 CFR 52.47(b)(1).

9.2.1.4.4 Initial Test Program

DCD Tier 2, Section 14.2.12.1.34, describes the initial test program for the ESWS. Section 14.2 of this SE addresses the staff's evaluation of the initial test program for US-APWR.

9.2.1.5 Combined License Information or Activities (COL) Items

There are 15 COL information items identified by the applicant related to the ESWS. All of them were evaluated within Section 9.2.1.4 of this SE and the staff finds them adequate. A comprehensive reference list is located in DCD Tier 2 Chapter 9.2.10, with the corresponding item numbers used in this evaluation. No additional COL information items that should be in Table 1.8-2 of the DCD were identified by the staff.

9.2.1.6 Conclusions

The staff's evaluation of the ESWS for the US-APWR standard plant design is in accordance with the guidance that is referred to in the Regulatory Basis Section 9.2.1.3 of this SE. The staff's review included information in the DCD as supplemented by the applicant's responses to numerous RAIs, which have been incorporated in Interim Revision 4 of the DCD used for this SE.

The staff's review finds that the applicant appropriately identified heat load and flow requirements for safety-related components as well as for the system as a whole in various relevant modes of operation. The staff finds that the US-APWR four safety-related train design with a minimum of two trains required provides inherent tolerance to single failures.

The staff's review also included the ESWS ITAAC, pre-operational testing and TS and finds that these sections provide reasonable assurance that the ESWS will be inspected, tested and operated in accordance with the ESW system design basis.

Based on the review summarized above, and the close out of one (1) outstanding **confirmatory item** (Interim Revision 4), the staff concludes that the ESWS design is consistent with the guidance of NUREG-0800, SRP 9.2.1, and that the information provided by the applicant adequately demonstrates that the requirements of 10 CFR Part 50, Appendix A, GDCs 4, 5, 44, 45, 46, and 10 CFR 20.1406 are met. In addition, the staff concludes that if the ESWS interface requirements are met and the ITAAC for ESWS are performed and the acceptance criteria met, there is reasonable assurance of operation in accordance with the DC, the provisions of the Atomic Energy Act of 1954, and the NRC's regulations, which include 10 CFR 52.47 (b)(1), 10 CFR 52.47(a)(24), and 10 CFR 52.47(a)(25).

Open item related to boundary valve AOV-577 needs to be resolved; therefore, the staff cannot find that GDC 2 requirements have been satisfied.

9.2.2 Component Cooling Water

9.2.2.1 Introduction

The CCWS is a closed loop cooling water system that removes heat from safety-related and non-safety related components during normal operating, accident, refueling, and shutdown conditions. The heat transferred from these components to the CCWS is rejected to the ESWS via the CCW HXs.

The CCWS consists of two independent subsystems with each subsystem providing 100 percent of the cooling capacity required for its safety function. Each of the two subsystems contains two fifty percent trains for a total of four safety-related 50 percent trains with the principal equipment of each train located in its separated area in the RB.

Each of the two subsystems (trains A & B, trains C & D) consists of two CCWS pumps, two plate type CCWS HXs, a surge tank, and three sampling lines with a continuous radiation monitor. CCWS surge tank makeup water can be supplied from three sources; DWS, primary makeup water system (PMWS), and fire protection water supply service (FSS). The CCWS includes supply headers A, B, C, D, A-1, A-2, C-1 and C-2 for providing cooling water to both safety-related and non-safety related loads.

The following loads are served by the CCW supply headers A, B, C and D:

- Containment spray/residual HXs.
- Containment spray/RHR pump motors.
- Safety injection pump.
- CCW pump motors.

The CCWS provides cooling water for other loads via headers A-1 or C-1, which includes:

- SFP HXs.
- Charging pumps (CVCS.
- Atmosphere gas sample coolers (C-1 only).
- Sample HXs.
- Reactor coolant pumps.

The CCWS provides cooling water for other loads via headers A-2 or C-2, which includes;

- Blowdown sample coolers.
- Seal water HXs.
- Instrument air systems.
- Excess letdown and letdown HXs.
- Waste gas dryers.
- Chemical drain tank pumps.
- BA evaporators.
- Auxiliary stream drain monitor HXs.

Each safety-related CCWS train is powered by a Class 1E electric bus. On a LOOP, emergency power is provided from its associated GTG.

Portions of the CCWS are designed to Seismic Category I requirements so as to remain functional during and following a SSE. The CCWS is designed to perform its safety function of accident mitigation assuming that one 50 percent train is out of service for maintenance coincident with the LOOP and a single failure in another train.

During severe accidents, alternative methods of charging pump cooling using CCWS connections are available from water supplied by the non-essential chilled water system (non-ECWS) or the FSS. In addition, the CCWS can be used as an alternative supply of cooling water to the containment fan coolers of the non-ECWS.

9.2.2.2 Summary of Application

DCD Tier 1: The CCWS is described in Tier 1, Section 2.7.3.3, “Component Cooling Water System.” The functional arrangement of the CCWS is shown in DCD Tier 1, Figure 2.7.3.3-1, Sheets 1 and 2. Design information is provided in DCD Tier 1, Table 2.7.3.3-1, which provides physical locations and system equipment. Equipment characteristics and piping characteristics are provided in DCD Tier 1, Table 2.7.3.3-2 and Table 2.7.3.3-3, respectively. Main MCR and remote shutdown console (RSC) alarms and displays are identified in DCD Tier 1, Table 2.7.3.3-4.

DCD Tier 2: The CCWS and its design bases are described in detail in DCD Tier 2, Section 9.2.2 and Figure 9.2.2-1 (nine sheets). Associated with CCWS, Tier 2 also includes Table 9.2.2-1 through Table 9.2.2-7.

ITAAC and Initial Plant Testing: ITAAC for the CCWS are included in DCD Tier 1, Table 2.7.3.3-5. Initial plant testing for the CCWS is described in DCD Tier 2, Section 14.2.12.1.87, “Component Cooling Water System Preoperational Test.” A discussion of the ITAAC and the pre-operational tests is provided in Section 9.2.2.4, “Technical Evaluation,” of this SE.

TS: TS for the CCWS are provided in DCD Tier 2, Section 16 TS 3.7.7. A discussion of TS 3.7.7, as it relates to the CCWS, is provided in Section 9.2.2.4 of this SE.

9.2.2.3 Regulatory Bases

The relevant requirements of the NRC Regulations for this area of review, and the associated acceptance criteria are given in SRP Section 9.2.2 of NUREG-0800, Revision 4, issued March 2007, and are summarized below. Review interfaces with other SRP sections can be found in Section 9.2.2 of NUREG-0800.

GDC 2, “Design Bases for Protection against Natural Phenomena,” as related to structures housing the system and the system itself having the capability of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes and floods without loss of safety-related functions.

GDC 4, “Environmental and Dynamic Effects Design Bases,” as to effects of missiles inside and outside of containment, pipe whip, jets, and environmental conditions from high and moderate energy line breaks and dynamic effects of flow instabilities and loads (e.g., water hammer) during normal plant operation, as well as during accident conditions.

GDC 5, “Sharing of Structures, Systems and Components,” insofar as it requires that SSCs important to safety not be shared among nuclear power units unless it can be shown that sharing will not significantly impair their ability to perform their safety functions.

GDC 44, “Cooling Water,” as it relates to requirements for the transfer of heat from SSCs important to safety to a heat sink during both normal and accident conditions assuming a single failure. Suitable redundancy in components shall be provided to assure that for onsite electric power system operation (assuming offsite power is not available) and for offsite power systems operation (assuming onsite power is not available) the system safety function can be accomplished, assuming a single failure.

GDC 45, “Inspection of Cooling Water System,” as it relates to design provisions for appropriate periodic inspection of important components, such as HX and piping, to assure continued system integrity and functional capability.

GDC 46, “Testing of Cooling Water Systems,” requires that the cooling water system shall be designed to permit appropriate pressure and functional testing.

10 CFR 52.47(b)(1), which requires that a DC 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’s regulations.

Additional requirements are not described in SRP 9.2.2: 10 CFR 20.1406, “Minimization of contamination,” as it relates to the design features that will facilitate eventual decommissioning and minimize, to the extent practicable, the contamination of the facility and the environment and the generation of radioactive waste.

9.2.2.4 Technical Evaluation

The staff’s evaluation of the CCWS is based upon the information provided by the applicant in a letter dated October 14, 2011, “Markup for US-APWR DCD Revision 4, Section 9.2,” which transmitted DCD Tier 2, Section 9.2.2, Interim Revision 4. This letter also provided DCD markups for other Tier 1 and DCD Tier 2 sections applicable to the review of DCD Tier 2, Section 9.2.2.

For CCWS, the staff requested that the applicant respond to questions in 50 RAIs that based on the information in DCD Revisions 0, 1, 2 and 3 that described the design, operation, and testing of the CCWS. The applicant answered these questions in numerous responses that included DCD markups that the staff reviewed and finds acceptable. In an October 14, 2011, the applicant provided the DCD Interim Revision 4 markup for the applicable DCD sections. The staff reviewed the response and confirmed that the DCD Interim Revision 4 markup, dated July 29, 2011, contains all of the relevant CCWS RAI responses. In this SE, the staff is not describing every staff RAI and applicant response. The staff’s technical evaluation is based on review of the DCD Interim Revision 4 markup for the applicable sections. In some cases, RAI responses are discussed where clarifying information was not described in the DCD markup. To ensure that the DCD Interim Revision markup information is incorporated in the latest revision of the DCD, **the October 14, 2011, letter is being tracked as a confirmatory item.**

GDC 2

DCD Tier 2, Section 3.2, “Classification of Structures, Systems and Components,” identifies the SSCs based on safety importance and other considerations. Table 3.2-2, “Classification of Mechanical and Fluid Systems, Components, and Equipment,” provides the component safety classification, seismic classification, quality group classification, comment commercial codes and locations for the SSCs.

For seismic consideration, information that addresses GDC 2 will be considered acceptable for Section 9.2.2 if the guidance of RG 1.29, “Seismic Design Classification,” Position C.1 for safety-related and Position C.2 for non-safety related portions of the CCWS are met. Other considerations are addressed below such as flooding and missiles protection.

The staff finds that the safety classification, quality group, seismic category and location for the CCWS components are properly designated. All safety-related portions of the CCWS are located inside buildings that are Seismic Category I, tornado-, missile-, and flood-protected, which for this system, are the RB and PCCV. The system is also designed to ensure that failure of any non-safety related portions of the system does not adversely impact any safety function of the CCWS.

Valves for isolating the safety-related from the non-safety related portions of the system are air operated isolation valves in series (NCS-AOV-057A/B and NCS-AOV-058A/B) which are designed to fail “closed” on loss of power. These valves close on low-low surge tank level, “S” signal and/or “P” signal. In addition, there are two check valves in series (NCS-VLV-036A/B and NCS-VLV-037A/B) which isolate the return side of the safety-related to non-safety boundary. These eight valves are located on the RB side of the boundary between Seismic Category I and non-safety piping.

The staff’s evaluations of protection provided for the SSCs which are important to safety are included in the following sections of this SE:

- Section 3.4.1 of this SE addresses the staff’s evaluation of flood protection provided for the SSCs which are important to safety.

- Section 3.5.1.1 of this SE addresses the staff’s evaluation of protection provided for the SSCs which are important to safety from internally generated missiles outside containment.

- Section 3.5.1.2 of this SE addresses the staff’s evaluation of protection provided for the SSCs which are important to safety from internally generated missiles inside containment.

- Section 3.5.1.4 of this SE addresses the staff’s evaluation of protection provided for the SSCs which are important to safety from missiles generated by natural phenomena.

- Section 3.5.2 of this SE addresses the staff’s evaluation of protection provided for the SSCs which are important to safety from externally generated missiles.

- Section 3.12.3.7 of this SE addresses the staff’s evaluation of protection provided to prevent non-seismic lines and equipment from having adverse interactions with the SSCs which are important to safety. DCD Tier 2, Section 3.12.3.7, “Non-seismic/Seismic Interaction (II/I),” identifies acceptable methods to address the potential for interaction between seismic qualified and non-seismic qualified portions of the CCWS that are routed through the same areas, such as the RB.

Tier 2 US-APWR DCD, Table 9.2.2-4, “Component Cooling Water System Heat Load,” described that during startup and refueling operations it is possible to have two CCWS pumps in operation, coming off a common CCWS surge tank with an internal baffle plates. In this plant configuration, along with a single passive pipe leak path of the common safety-related header, and with the header tie isolation valves open (MOV-007A/B/C/D and MOV-020A/B/C/D), it is possible to drain both sides of the CCWS surge tank at the same time. A postulated pipe leak path has a potential to drain the CCWS surge tank, assuming non-safety related makeup is not available, and causing two trains of CCWS to become unavailable.

The staff has generated Letter Number 878 (RAI-6200, Question 9.2.2-85), for the applicant to address the following in Section 9.2.2 of the DCD:

- Describe in the DCD how the US-APWR is designed against postulated piping leak paths in the safety-related portions of the CCWS. Also describe the bounding conditions related to piping leak size and locations.

- Describe in the DCD the consequences of such a piping leak path in the common CCWS, looking at various modes of operations, assuming the header tie isolation valves are open.

- Describe in the DCD any operator actions necessary to prevent the potential loss of two trains of CCWS once a 'low' or 'low-low' CCWS surge tank level setpoints are reached. Also describe the operator time requirements to achieve CCWS train isolation knowing there is greater than 800 gallons between the 'low-low' level set point and '0' indication in the CCWS surge tank.

- Describe in Table 9.2.2-3, "Component Cooling Water System Failure Modes and Effects Analysis," this failure mode and the effects on the CCWS system safety function.

RAI 6200 remains an open item - Pending the resolution of open item discussed above and based on the above considerations which specifically address GDC 2, the staff finds that the CCWS complies with the relevant guidance of RG 1.29, Regulatory Position C.2 as it pertains to the requirements of GDC 2. Also, because safety-related parts of the CCWS have been properly identified and designated as Seismic Category I, the staff finds that the CCWS complies with the relevant requirements of GDC 2 as it pertains to RG 1.29, Regulatory Position C.1.

GDC 4

The staff reviewed the CCWS, to determine if the design complies with the relevant requirements of GDC 4. Section 3.6.1 of this SE addresses the staff's evaluation of the design of structures, shields, and barriers necessary for the SSCs to be protected against dynamic effects of high-energy line breaks. Based on the staff's evaluation discussed in Section 3.6.1 of this SE, the staff finds that the CCWS is protected against the effects of, and is compatible with, the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents.

In addition, the staff reviewed the CCWS description to confirm that the applicant has adequately addressed water hammer considerations. Two of the four safety-related trains are normally in operation (trains A or B and trains C or D) with the remaining two trains in standby. During a plant shutdown or refueling outage, three or four CCWS trains may be in operation at the same time as described in Tier 2, DCD Section 9.2.2.2.2, and Table 9.2.2-4. As stated in Tier 2, DCD Section 9.2.2.1.1, the CCWS is protected against adverse environmental, operating, and accident conditions that can occur, such as flooding, HELB, thermal over-pressurization, and water hammer. In addition, Section 9.2.2.3, states that the CCWS is a closed system that is maintained in a water solid condition with a surge tank located at the highest point in the system which is designed to prevent water hammer.

DCD Tier 2 Section 9.2.2.2.2.6, “Water Hammer Prevention,” states that the CCWS is designed in consideration of the water hammer prevention and mitigation in accordance with the following as discussed in NUREG-0927, “Evaluation of Water Hammer Occurrence in Nuclear Power Plant”:

- An elevated surge tank to keep the system filled.
- Vents for venting components and piping at all high points in the system.
- After any system drainage, venting is assured by personnel training and procedures.
- System valves are slow acting.

The CCWS is under pressure due to the static water head of the surge tank. In case of an earthquake, CCWS piping in non-earthquake resistant buildings may break. However, voiding and associated water hammer potential will not develop even if the pressure is reduced to an atmospheric level in the broken section because the CCWS water temperature is less than the saturation temperature at atmospheric pressure. Moreover, as isolation valves to the non-earthquake resistant buildings close because of low-low surge tank water level, the surge tank maintains a static water head. Thus, voiding is unlikely to occur in the event of pipe breaks.

The COL applicant, in COL Information Item 9.2(27)), is to develop a milestone schedule for implementation of the operating and maintenance procedures for water hammer prevention. The procedures should address the operating and maintenance procedures for adequate measures to avoid water hammer due to a voided line condition.

SRP 9.2.2 states that the design provisions presented in NRC GL 96-06, “Assurance of Equipment Operability and Containment Integrity during Design - Bases Accident Conditions and Water Hammer,” should be appropriately addressed to include the following concerns:

1. Cooling water systems serving the containment air coolers may be exposed to the hydrodynamic effects of water hammer during either a LOCA or a main steam-line break (MSLB). These cooling water systems were not designed to withstand the effects of water hammer.
2. Cooling water systems serving the containment air coolers may experience two-phase flow conditions during a postulated LOCA or MSLB scenarios. The heat removal assumptions of a design-basis accident (DBA) scenario were based on single-phase flow conditions.
3. Thermally induced over-pressurization of isolated water-filled piping sections in the containment could jeopardize the function of accident mitigation systems and could also lead to a loss of containment integrity.

The staff finds that for the US-APWR CCWS design, there is no CCWS flow to the containment air coolers (also known as containment fan coolers for the US-APWR DCD) since the containment air coolers are normally supplied by the Non-ECWS, which is discussed in Section 9.2.7 of this SE. Therefore, GL 96-06 Items 1 and 2 discussed above, related to the containment air coolers, do not apply to the US-APWR design.

Related to GL 96-06 Item 3, the CCWS lines penetrate the containment at eight points: two cooling water supply lines and two cooling water return lines for the Reactor Coolant Pumps (RCPs), one cooling water supply line and one cooling water return line for the excess letdown HX, and one cooling water supply line and one cooling water return line for the letdown HX. Upon occurrence of a LOCA, these cooling water lines for the letdown and excess letdown HX are isolated in response to a containment isolation signal. Containment penetration over-pressurization protection for the letdown and excess letdown HX cooling lines is provided by system relief valves as shown on DCD Tier 2, Figure 9.2.2-1, Sheet 8. As for the CCWS RCP cooling water lines, these containment isolation valves do not close on any accident signals; thus, this flow path is not subject to water hammer due to continuous CCWS flow to the RCPs.

The staff determined that, for the cooling water lines for the excess letdown HX and letdown HX, water flow is not resumed after closure of the isolation valves as these lines are not used after containment isolation. Thus, the excess letdown HX and letdown HX are not subject to water hammer due to resumption of water flow or subject to system over-pressurization since system relief valves are installed at the containment penetrations as shown on Figure 9.2.2-1.

DCD Tier 2 Section 9.2.2.2.1.2 and Section 9.2.2.2.1.3, describe the CCWS surge tank. The CCWS surge tank is located at a higher elevation than the CCWS pumps. Related to CCWS voiding, the staff determined that the CCWS is under pressure due to the static water head of the surge tank. In case of an earthquake, CCWS piping in non-earthquake resistant buildings may break. However, voiding will not develop even if pressure is reduced in the broken section to atmospheric because the CCWS water temperature is less than the saturation temperature at atmospheric pressure. Moreover, as isolation valves close to the non-earthquake resistant buildings because of low-low surge tank water level, the surge tank maintains a static water head. Thus, voiding is unlikely to occur in the event of pipe breaks.

Related to possible pressure transients on the plate type HXs (over-presssurizations), the typical operating practice when starting and stopping the CCW pumps is as follows. This information was provided in a response to **RAI 571-4365, Question 09.02.02-50,** which states:

- Pump discharge valves (NCS-VLV-018A/B/C/D) are first closed. The discharge valves are manually controlled by plant personnel at the valve location. Because of their large size (24”), the rate of closure of a manual discharge valve is not so fast as to cause sudden increase in pressure or pressure differentials in the pump discharge piping. Thus, the potential for water hammer is minimized.

- If the pump is required to be available for automatic start, the pump discharge valves are then reopened to assure an open flow path.

- If the pump is not required to be available for automatic start (e.g., when it is out-of service for maintenance), the pump discharge valves are closed (which also isolates the associated HX from the other train). Based on operating experience, pressure relief vents are not used because the system design takes the pump head-flow curve into account. Similarly, there has been no indication that dampening devices are required to minimize pressure transients.

> However, the method of pump start/stop is an operational decision and is not discussed in the DCD. The method of pump start/stop assuming an open discharge valve is acceptable from a system design perspective. If the pump were stopped with the discharge valves remaining open, check valves (NCS-VLV-016A/B/C/D) gradually close as flow decreases. System conditions and the potential impact forces are considered in the valve design. The HX remains exposed to pressure from the operating train; thus, the pressure-transient across the HX will be minimized and equalizes based on check valve closure. Verification that there are not unacceptable water hammers or pressure waves detected with pump operation (start/stop) is addressed in DCD Tier 2, Section 14.2.12.1.87.

The staff determined that the CCWS pressures and potential impact forces were appropriately considered in the CCWS design. Testing for potential water hammer and system pressure waves are to be addressed by pre-operational testing. Under DCD Tier 2, Section 14.2.12.1.87, verification will be performed to verify that there is no unacceptable water hammer, excessive vibration, excessive noise, on unacceptable pressure waves associated with pump discharge check valve functions and that the CCWS SSCs, including the plate type HX gaskets, design values are not exceeded. The CCWS is verified to be adequately designed for these potential conditions during CCWS pump starts and stops.

The CCWS has several penetrations that penetrate containment, which include the cooling and return lines for the RCPs (A, B, C and D pumps), the excess letdown HX, and the letdown HX. The actuation signal for each of these penetration isolation valves is listed in Tier 2, DCD Table 6.2.4-3, “List of Containment Penetrations and System Isolation Positions,” which includes containment vessel spray signal pressure for the penetration isolation valves associated with the RCPs and safety injection signal for the letdown and excess letdown HXs. Isolation valves provided on the CCWS lines that penetrate the containment vessel addressing GDC 55 and GDC 57 are addressed in Section 6.2.4 of this SE.

Accordingly, based on the preceding discussion, the staff concludes that the CCWS meets the requirements of GDC 4, including GL 96-06 and water hammer consideration for the CCWS.

GDC 5

The US-APWR standard plant design is a single-unit station and, consequently, there are no shared safety-related SSCs between different units. Therefore, the provisions of GDC 5 are not applicable to the US-APWR standard plant design.

GDC 44

General:

The CCWS must be capable of removing heat from SSCs important to safety during normal operating and accident conditions over the life of the plant in accordance with GDC 44. The following CCWS design considerations were evaluated to determine if the CCWS is capable of performing its functions in accordance with this requirement.

DCD Tier 2, Section 9.2.2.2.4, states that, at a minimum, two trains are required to operate during a LOCA.

DCD Tier 2, Figure 9.2.2-2, “Component Cooling Water System Modes Diagram,” (Sheets 1 through 6) provides detailed system parameters for all six CCWS operating modes, which includes; startup, power operations, refueling, cooldown, accident, and safe shutdown. The six figures include flow diagrams identifying system locations and tables listing the detailed pressure, temperature, and flow-rate conditions for each system node location for each of these six operating modes.

The staff reviewed Figure 9.2.2-2 and found it acceptable since the applicant provided detailed pressure, temperature, and flowrate conditions for each system location (or node) for each CCWS mode of operation. In addition, a note was added to several of the figures stating that under accident and safe shutdown conditions, the operator would have to manually close the CCWS header tie valves (NCS-MOV-007A/B/C/D and NCS-MOV-020A/B/C/D) from the MCR to provide train isolation and separation. The staff validated these data against DCD Tier 2, Table 9.2.2-5, which summarizes the CCWS total flow balance rates.

DCD Tier 2, Table 9.2.2-7, “Electrical Power Division of Remotely Operated Valves,” describes the safety related CCWS valves and its 1E electrical power supplies. The staff finds this table acceptable since Table 9.2.2-7 clarifies the safety related valves and appropriate power supplies. Further, the staff reviewed this table and determined that, for train separations and single failure criteria, those valves that are in series and have to perform active functions, have been adequately designed with different power supplies. For example, NCS-AOV-057A and NCS-AOV-058A are in series and provide isolation between the safety related portion of the CCWS and the non-safety related portion. These valves receive active closure signals from low-low surge tank level, ECCS actuation signal “S”, and high containment pressure signal “P”, have “DA” and “DD” Class 1E-125v dc power supplies, respectively.

HXs:

DCD Tier 2, Section 9.2.2.2.1.1, states that CCW HXs transfer heat from the CCWS to the ESWS. The CCWS HXs are designed to remove heat loads associated with all modes of operation. The “design” condition is associated with CCWS and ESWS flow rates of 41,640 liter/min (11,000 gpm), a maximum CCWS design outlet temperature of 37.8 °C (100 °F) and maximum cooling water inlet temperature from ESWS of 35 °C (95 °F). At the design condition, the heat removal capacity of each CCWS HX is 52.8 gigajoule/hr (50 x 10^6 Btu/hr).

The HXs are sized to provide cooling water no greater than 37.8 °C (100°F) during normal power operation (DCD Tier 2, Section 9.2.2.1.2.1), no greater than 43.3 °C (110 °F) during shutdown operation (DCD Tier 2, Section 9.2.2.1.2.2) and no greater than 51.7 °C (125 °F) during accident (DCD Tier 2, Section 9.2.2.1.2.5) and safe shutdown conditions (DCD Tier 2, Section 9.2.2.1.2.6). The assumed ESWS temperature is 35 °C (95 °F) for all operating conditions. HX fouling factors are in accordance with manufacturer's standards and the system water chemistry.

DCD Tier 2, Section 9.2.2.2.1.1, states that the CCWS plate-type HX “design” heat removal capacity of 52.8 gigajoule/hr (50 x 10^6 BTU/hr) allows removal of the normal operating heat load using two HXs. The design heat load is determined by summing individual user requirements, which are listed in Table 9.2.2-6. The heat load from the SFP is based on the decay heat for the design SFP loading as described in Section 9.1.3.1, calculated by ANSI/ANS 5.1; the decay heat predicted by ANSI/ANS 5.1 is larger than ORIGEN 2.2 output. Thus, the SFP HX heat load shown in Table 9.2.2-6 used for CCWS design is conservative by about 6.3 gigajoule/hr (6 x 10^6 Btu/hr) in comparison to ORIGEN 2.2 predictions. As a result, there is a net 10 percent margin in the CCWS design heat removal capacity due to the conservatism in the SFP HX load. In addition, vendor design margin for the HX area is a minimum of 20 percent over the area associated with the design heat removal capacity.

Actual HX performance based on these design considerations will reflect the temperature differential across the heat exchange surface (delta-T) and the product of the overall heat exchange coefficient and heat exchange area (UA). The heat exchange area, A, is not dependent on the CCWS operating mode; however, U and delta-T will change due to changes in flow rate or temperature conditions in each heat exchange configuration. Table 9.2.2-4 and Table 9.2.2-5 provide heat loads and flow rates, respectively, for various CCWS operating modes.

The staff finds that the CCWS plate-type HXs have a “design” capacity of 52.8 gigajoule/hr (50 x 10^6 BTU/hr) to allow removal of the normal operating heat load using two HXs. The design heat load is determined by summing the individual user requirements, which are listed in DCD Tier 2, Table 9.2.2-6. The SFP HX load is based on ANSI/ANS 5.1 decay heat modeling, which predicts about 10 percent larger decay heat than ORIGEN 2.2 output. That is, the heat load shown in Table 9.2.2-6 for the SFP percent HX is 21.4 gigajoule/hr (20.3 x10^6 Btu/hr), based on the design SFP loading described in Section 9.1.3.1; this heat load exceeds the ORIGEN 2.2 output by about 6.3 gigajoule/hr (6 x10^6 Btu/hr). The design CCWS HX capacity is 52.8 gigajoule/hr (50 x10^6 Btu/hr); therefore, there is approximately a 10 percent margin (6.3/52.8) in the CCWS design heat removal capacity. Additionally, vendor design margin for HX area has a minimum of 20 percent over the design HX area of 1,028 m^2 (11,068 ft^2) which was provided in the attached Table 9.2.2.52-1 in the response to **RAI 571-4365, Question 09.02.02-52**. Actual HX performance based on these design considerations will reflect the temperature differential across the heat exchange surface (ΔT) and the product of overall heat exchange coefficient and area (UA). The heat exchange area “A” does not change for the required condition; however “U” and “ΔT” will change due to changes in flow rate or temperature differential in each heat exchange condition. Table 9.2.2.52-1 summarizes HX performance for the key operating conditions. As indicated in the table, the “design” condition of 52.8 gigajoule/hr (50 x 10^6 BTU/hr) is associated with CCWS and ESWS flow rates of 41,640 liter/min (11,000 gpm), consistent with DCD Table 9.2.2-2. The maximum CCWS design outlet temperature is 37.8 °C (100 °F) and maximum cooling water inlet temperature from ESWS is 35 °C (95 °F). These are the design conditions that are used for normal operation. Other operating conditions and the resultant heat transfer rates are shown in the attached Table 9.2.2.52-1.

In summary, the staff determined that the CCWS HX is adequately designed to support all modes of operations and has adequate margins. Specifically, during a DBA, only two trains of any four trains are required.

Pumps:

DCD Tier 2, Section 9.2.2.2.1.2, states that the CCWS pumps are designed in consideration of head losses in the cooling water inlet piping based on full power flow conditions, increased pipe roughness, maximum pressure drop through the system HXs, and the actual amount of excess margin. The design head and flow rate of the CCWS pumps are provided in two DCD Tier 2 Table 9.2.2-2. The design head is calculated based on supplying cooling water to the RCP thermal barriers, which is the line having the most severe pressure loss. The pumps have a design head of 0.53 MPa (180 ft water) which ensures a minimum of 5 percent margin over the head required to account for the pressure loss of this line at the design flow rate. The designed flow rate of 45,424 lpm (12,000 gpm) is at least 20 percent larger than that required for any CCWS operational mode, as indicated in Table 9.2.2-5.

The staff finds the CCWS pump design parameters acceptable. There is an approximate 5 percent margin in pump head at design conditions and an approximate 20 percent margin in CCWS pump flow at accident conditions, which accounts for degradation over time. Based on the pump curves provided by the applicant in the response to RAI 571-4365, Question 09.02.02-53, the required head for the CCWS pump for accident or safe shutdown conditions is approximate 51.8 m (170 ft) which adds additional margin since the pump is designed with margin at 57.9 m (190 ft). In summary, the staff determined that the CCWS pump is adequately flow-and-head-designed to support all modes of operations and has adequate margins.

Single Failure:

The CCWS must be capable of performing its safety functions assuming a single failure with and without off-site power available in accordance with GDC 44 requirements. Only two CCWS trains are needed for accident mitigation and the four train CCWS design provides redundancy. DCD Tier 2 Table 9.2.2-3, “Component Cooling Water System Failure Modes and Effects Analysis,” describes failure modes which include single active failures.

Each train of CCWS is independent of any other train with the exception of normally closed motor operated RCP cross-tie isolation valves (NCS-MOV-232A/B and MOV-233A/B) between common headers A-1 and C-1 for the RCP, which includes cooling to the RCP thermal barrier. Also, upon a LOOP, each CCWS train receives power from its respective GTG. Therefore, a single failure will only affect one train and will not compromise the capability of the CCWS to perform its safety functions with and without offsite power available. Additionally, the four safety train design provides sufficient redundancy such that design basis accident mitigation capability is maintained in the event that there is a failure associated with one train with another train out of service for maintenance. Also, in case of loss of onsite power to one electrical division, there are three other independent safety electrical divisions to support the other remaining CCWS divisions.

DCD Tier 2, Section 9.2.2.2.1.5, states that these normally closed motor operated valves (NCS-MOV-232A/B and MOV-233A/B) are manually opened from the MCR in the event that CCWS flow is interrupted to the RCP motors and thermal barriers due to a single failure of one train while the second train in the same subsystem is undergoing on-line maintenance. Valve opening allows CCWS flow to the affected RCP thermal barriers and motor bearing oil coolers from the alternative subsystem. The supply valves connecting to the alternative CCWS subsystem are NCS-MOV-232A/B; the return valves are NCS-MOV-233A/B. The valves are operated in conjunction with an RCP CCWS return line isolation valve (NCS-MOV-234A/B) to establish the alternative flow path. DCD Tier 2, Table 9.2.2-3 states under item 1 that opening the RCP cross tie isolation valves provides a flow path for RCP cooling if there is a failure of the operating train in the same subsystem that has another train in a maintenance outage.

DCD Tier 2, Table 9.2.2-4, Note 1 states that if one subsystem is unavailable (e.g., one train is unavailable due to on-line maintenance and a single failure occurs in the other train of that subsystem), the operator will open the RCP header tie line isolation valves to provide cooling from the operating subsystem to the RCP thermal barriers of the unavailable subsystem. The additional heat load from the two RCP thermal barriers is 2.6 gigajoule/hr (2.5 x 10^6 Btu/hr) placed on the operating subsystem.

The staff reviewed the RCP crosstie isolation valves and determined that the CCWS RCP cross ties are required to be opened within 10 minutes only when one of the four trains of CCWS is isolated for maintenance and there is a failure in the operating train of that subsystem since it is desired to continue to operate the RCPs. For example, CCWS A and C are running with the unit at power with CCWS D out of service and CCWS C pump trips. If CCWS flow is lost and cannot be restored within 10 minutes, the RCPs will be tripped following a reactor trip. Even if there is a loss of CCWS, seal injection flow continues to be provided to the RCP. Seal injection flow from the CVCS is sufficient to prevent seal damage even with a loss of thermal barrier cooling. However, loss of CCWS to a RCP motor bearing oil cooler will result in a high temperature trip of the RCP motor cooler, which is described in DCD Tier 2, Section 5.4.1.3.4. The CCWS RCP cross tie valves (NCS-MOV-232A/B, NCS-MOV-233A/B, and NCS-MOV-234A/B), are motor-operated and can be remotely operated from the MCR. Because these valves are slow to open or close (greater 30 seconds) potential water hammer can be avoided. In addition, the open/close positions of the valves are displayed in the MCR. In addition, the added heat load to the operating HX while the RCP crosstie is open is well within the HX margins previously addressed above.

Sections 5.4.1 and 8.4 of this report further describe the RCP seals during normal and station blackout (SBO) conditions. This includes the loss of seal injection and the loss of CCWS to the RCP seals and RCP thermal barrier and a complete loss of both seal injection and CCWS.

Also related to single failure, DCD Tier 2 Section 9.2.2.2.1.5, states that for the header tie line isolation valves (NCS-MOV-007A/B/C/D and NCS-MOV-020A/B/C/D) each safety train has both supply and return header tie line isolation valves so that a single failure of one of the safety trains will not impact the other safety trains. The function of this motor operated valve is to separate each subsystem into two independent trains during abnormal and accident conditions. This ensures each safety train is isolated from a potential passive failure in the non-safety related portion or another safety train of the CCWS. These valves are operated from the MCR when an operator determines that train separation is required.

DCD Tier 2, Table 9.2.2-4 , entitled “Component Cooling Water System Heat Load Unit of Heat Load [x106Btu/hr],” provides the total “A or B header/C or D header” heat load as 170.6 gigajoule (161.7 x 10^6 BTU/hr) for the accident condition and 201.4 gigajoule (190.9 x 10^6 BTU/hr) for safe shutdown. Adding 1.39 gigajoule (1.32 x 10^6 BTU/hr), which is derived from DCD Tier 2, Table 9.2.2-6, to account for short term (less than 24 hours) open header tie line isolation valves and a single failure would increase this value to 172 gigajoule (163.02 x 10^6 BTU/hr) (an increase of 0.8 percent) for the accident condition and 202.8 gigajoule (192.2 x 10^6 BTU/hr) (an increase of 0.7 percent) for the safe shutdown. This value would slightly increase the required HX UA value for accident and safe shutdown condition; however, such a change would not affect the design basis of the CCW HX as it is small in comparison to the required UA value. Thus, the system would not overheat in this configuration as the available HX could accommodate the increased heat load. In addition, as discusses earlier, vendor design margin for the HX area is a minimum of 20 percent over the area associated with the design heat removal capacity.

The staff determined in its review that eight valves (NCS-MOV-007A/B/C/D and NCS-MOV-020A/B/C/D), that are normally open and without an active closure signal, that during an accident condition are susceptible to the potential for additional loading on one train of a subsystem if a single failure is postulated in the other train. The potential exists only for the period in which the header tie line valves are open until the MCR operators close the applicable MOVs. For example, if the B CCWS pump fails to actuate upon the receipt of an ECCS actuation signal, the heat load on the A CCWS HX will be increased by 1.39 gigajoule (1.32 x 10^6 BTU/hr).

DCD Tier 2, Section 9.2.2.2.2.4 states that all CCWP pumps are automatically actuated by an ECCS actuation signal. The pump start signal has a 10-second time delay for load sequencing. The isolation valves for the CS/RHR HXs are automatically opened by the ECCS actuation signal and the same train CCWP start signal. The header tie line isolation valves are not automatically closed on an ECCS signal so that flow is not interrupted to the RCP thermal barriers coolers. The header tie line isolation valves must be closed by operator action to separate the CCWS into four trains (A, B, C and D). The COL Applicant is to develop a milestone schedule for implementation of the emergency operating procedures (EOPs) to assure that the necessary header tie line isolation valves are closed within 24 hours after an event to achieve train separation (see COL Information Item 13.5(6)). As a minimum, two trains are required to operate during a LOCA.

The staff reviewed the 24 hour time limit for train separation and found it acceptable since operator actions are required to close the header tie line isolation valves within 24 hours to achieve train separation. The staff accepts the 24 hour duration to close the isolation tie lines since it is consistent with the SECY-77-439 (§2.D, “Passive Failure in a Fluid System”), SECY-77-439 refers to long-term cooling as “24 hours or greater after the event.” During the time frame that train are not separated and given a single failure of one CCWS pump, the additional heat loads for the remaining operable train is within the design margins of the HXs. The CCWS would not overheat in this configuration (as previously stated above) as the available HX could accommodate the increased heat load. The COL Applicant is to develop EOPs to address this condition when it is necessary to provide train separation.

In summary, the staff determined that the CCWS single failure criterion has been satisfied and Table 9.2.2-3 adequately describes the failure modes and effects related to essential components of the CCWS. For single failure during accident conditions, there is adequate margin for heat removal capacity of the CCWS HXs. CCWS train isolation between the A/B and C/D trains is achieved via manual operation from the MCR. Specifically, during a DBA, only two trains of any four trains are required.

NPSH and Surge Tank:

Each of the two CCWS subsystems (trains A/B or train C/D) is designed with a shared single CCWS surge tank. DCD Tier 2 Table 9.2.2-2 indicates that the surge tank volume is specified as 11.9 m^3 (420 ft^3). One CCWS surge tank, NCS-RTK-001A, services train A and B and the other CCWS surge tank, NCS-RTK-001B, services train C and D. In order to satisfy system flow requirements, the CCWS design must assure that the minimum NPSH for the CCWS pumps will be met for all postulated conditions, including consideration of vortex formation. DCD Tier 2 Section 9.2.2.2 describes that the CCWS surge tanks are located at a higher elevation (upper level of the RB) than the CCWS pumps (lower level of the RB). Calculations of available NPSH are based on conservative assumptions such as highest CCWS flow rate, highest surge tank temperature and lowest surge tank level. Using these conservative assumptions, the calculated NPSH is further reduced to define the design specification for the required NPSH of the CCWS pumps. This approach ensures that the CCWS pumps have flooded suction during all operating conditions and vortexing can be avoided.

The applicant responded to **RAI 571-4365, Question 09.02.02-57** by stating that the NPSH available for each CCWS operating mode is designed to be 0.21 Mpa (70 ft), which is based on

NPSH required at the rated flow rate of 45,424 lpm (12,000 gpm) plus 50 percent margin. The CCWS pumps are designed to have a required NPSH of 0.21 Mpa (70 ft) or less. In addition, the static water head used in the calculation of NPSH available as CCWS is based on an elevation difference of 38.1 meters (125 ft) from the surge tank outlet nozzle (which is lower than the low-low tank water level valve closure trip setpoint), to the pump suction nozzle; thus, this is conservative with respect to the actual elevation difference between the water level and pump suction. The available NPSH obtained by this elevation difference further includes a margin of 50 percent in the pump design (that is, NPSH available is reduced by 50 percent). Thus, the CCWS has adequate margin to avoid vortex suction at the pumps due to decrease in the surge tank water level. Also, the available CCWS pump NPSH is determined by the pressure loss in piping, static water head and saturated steam pressure in the CCW surge tank. Conservative values are used for each of these factors in the determination of available NPSH. Specifically, the suction piping pressure loss is based on the CCW pump rated flow of 45,424 lpm (12,000 gpm), which exceeds the required flow rate for any system operating mode. The assumed static water head is based on an elevation difference of 38.1 meters (125 ft) from the tank outlet nozzle to the pump suction, rather than the more realistic tank low-low water level. Saturated steam pressure is taken at the maximum water temperature of 65.6 °C (150 °F). In addition to these conservative assumptions, the available NPSH for pump design is assumed to be 50 percent less to provide additional margin, as stated earlier.

The staff reviewed the applicant’s response to **RAI 571-4365, Question 09.02.02-57.** Available CCWS pump NPSH is determined by the pressure loss in piping, static water head and saturated steam pressure in the CCW surge tank. The available NPSH obtained by this elevation difference includes a margin of 50 percent in the pump design (that is, NPSH available is reduced by 50 percent). The CCWS has adequate margin to avoid vortex suction at the pumps due to decrease in the surge tank water level.

In summary, the staff determined that the CCWS pump NPSH is adequately described and adequate margin is available. Conservative assumptions are included into the NPSH calculations such as higher water temperature, lower height of water, and higher system flow rates to achieve an acceptable margin.

Gas Accumulation:

Gas accumulation is addressed in Institute of Nuclear Power Operations (INPO) Significant Event Report 2-05, “Gas Intrusion in Safety Systems,” (specifically the San Onofre event) and information in GL 2008-001, “Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal and Containment Spray Systems.” DCD Tier 2 Section 9.2.2.2.1.3, states that the CCWS surge tank is covered with nitrogen gas to maintain water chemistry. The elevation of the surge tank and piping arrangement minimize the potential for nitrogen accumulation in places other than the surge tank.

The staff reviewed the potential for gas accumulation in the CCWS and found it acceptable since the elevation of the surge tank and piping arrangements minimizes the potential for nitrogen accumulation elsewhere other than the surge tank.

Containment Isolation:

DCD Tier 2 Section 9.2.2.1.5, states that containment isolation valves are installed on CCWS lines penetrating containment as described in Section 6.2.4. Containment isolation valves installed on the RCP coolant line that penetrates the containment (NCS-MOV-402A/B, NCS-

VLV-403A/B, NCS-MOV-436A/B, NCS-VLV-437A/B, and NCS-MOV-438A/B) are not automatically closed on a containment isolation signal in order to preserve flow to the RCP motor and seals. The open/close positions of the valves are displayed in the MCR where operators may control valve position as necessary.

The staff determined that this is an acceptable design arrangement since SRP 9.2.2, guidance states that the CCWS containment isolation valves to the RCPs thermal barrier are not to be isolated (only remote manual isolation is permitted) on an accident signal since continued long term pump operation maybe required in an actual event.

Section 6.2.4 of this report further describes the containment isolation valves.

CCWS Automatic Start Feature:

DCD Tier 2 Section 9.2.1.2.3.1 states that a low ESWS header pressure signal due to failure or tripping of an operating ESW pump is alarmed in the MCR. When the low ESWS header pressure alarm is annunciated, the standby ESW pump and the standby CCWS pump of the same train designation start automatically, ensuring continuous heat removal.

The staff finds this automatic start logic interlock between the ESWS and CCWS acceptable since it ensures that on a ESWS pump trip that the standby ESWS/CCWS pump pair is automatically started thus providing required heat removal. The CCWS/ESWS trains are paired in a manner similar to the paring of the CCWS surge tank pairs:

- If A ESWS train trips, B ESWS/CCWS trains automatically starts.
- If B ESWS train trips, A ESWS/CCWS train automatically starts.
- If C ESWS train trips, D ESWS/CCWS train automatically starts.
- If D ESWS train trips, C ESWS/CCWS train automatically starts.

Section 9.2.1 of this report further describes the ESWS trip logic.

CCWS Leakage and Surge Tank Sizing:

DCD Tier 2 Section 9.2.2.2.1.3, states that the CCWS is designed such that makeup to the surge tanks is not required for a minimum of seven days if the system is isolated. In addition, it states that, in the event that makeup water is not available, each CCWS surge tank compartment has a volume between the low-low level setpoint and the “0” instrument level of more than 3,028 liters (800 gallons). This is more than adequate to accommodate potential system leakage from pump seals and valves over a seven-day period.

In order to achieve this low out-leakage rate of the CCWS safety related pressure boundary, the applicant is utilizing low seat leakage criteria found from MSS-SP-61-1999 (Manufacturers Standardization Society SP-61-1999, “Pressure Testing of Steel Valves.)” The projected seat potential leakage rates through valves that isolate the safety from non-safety related piping are provided in the attached Table 9.2.2-49-1 which was part of the response to **RAI 571-4365, Question 09.02.02-49.**

The CCWS valves requiring low seat-leakage characteristics are:

- 12-inch NCS-AOV-057A and NCS-AOV-058A, in series, which isolate the A2 CCWS supply header to the non-safety related piping,

- 12-inch check valves NCS-VLV-036A and NCS-VLV-037A, in series, which isolate the A2 CCWS return header from the non-safety related piping,

- 10 inch NCS-AOV-057B and NCS-AOV-058B, in series, which isolate the C2 CCWS supply header to the non-safety related piping,

- 10 inch check valves NCS-VLV-036B and NCS-VLV-037B, in series, which isolate the C2 CCWS return header from the non-safety related piping,

- 3 inch valves NCS-MOV-321A and NCS-MOV-322A, in series, which isolate the A1 CCWS supply header from the non-safety related FSS,

- 3 inch valves NCS-MOV-324A and NCS-MOV-325A, in series, which isolate the A1 CCWS return header from the non-safety related FSS,

- 3 inch valves NCS-MOV-321B and NCS-MOV-322B, in series, which isolate the C1 CCWS supply header from the non-safety related FSS,

- 3 inch valves NCS-MOV-324B and NCS-MOV-325B, in series, which isolate the C1 CCWS return header from the non-safety related FSS,

- 3 inch valves NCS-MOV-323A and NCS-MOV-322A, in series, which isolate the A1 CCWS supply header from the non-safety related Non-ECWS,

- 3 inch valves NCS-MOV-324A and NCS-MOV-326A, in series, which isolate the A1 CCWS return header from the non-safety-related Non-ECWS,

- 3 inch valves NCS-MOV-323B and NCS-MOV-322B, in series, which isolate the C1 CCWS supply header from the non- safety-related Non-ECWS,

- 3 inch valves NCS-MOV-324B and NCS-MOV-326B, in series, which isolate the C1 CCWS return header from the non-safety-related Non-ECWS,

- 10 inch valves NCS-MOV-241, which isolate non-safety related Non-ECWS,

- 10 inch valves NCS-MOV-242 which isolate non-safety related Non-ECWS.

The total calculated seat leak rate is calculated to be less than 7.6 cc/min (0.002 gpm) for each CCWS subsystem. The potential total leakage through each CCWS subsystem (two trains) over a seven day period is less than 94.6 liters (25 gallons) as shown in the attached Table 9.2.2-49-1 **(RAI 571-4365, Question 09.02.02-49)**. Packing leakage is assumed to be small in comparison to potential seat leakage because of the valve design. Pump seal leakage per the design specification of 3 cc/hr/seal (two seals per pump times two pumps) results in a leakage rate of 0.2 cc/min (5.3 x10^{-5} gpm). A value of 189 liters (50 gallons) per CCWS subsystem (two trains) over a seven day period is conservatively used to account for boundary seat leakage, packing leakage and pump seal leakage. Using this value, makeup to the CCWS surge tank is not required for at least seven days after a seismic event.

TS 3.7.7 SR 3.7.7.2 and SR 3.7.7.3 assure that an adequate CCWS surge tank water volume is available at the start of a postulated accident so that CCWS surge tank makeup is not required for at least seven days. The TS value (described later in this SER) is conservatively determined by considering the surge tank water volume between the low-low level setpoint and the instrument zero level; the volume in this region exceeds 3,028 liter (800 gallons). Based on this volume, TS SR 3.7.7.2 will conservatively apply a SR of 11.4 liter/hour (gallon per hour) during the operating cycle; such a leak rate would be detectable, but would not result in the need for tank makeup for at least seven days. The instrument zero level is above the pump suction nozzle elevation used for CCWS pump NPSH calculations; the low-low level setpoint is below the normal operating level of the surge tank. TS SR 3.7.7.3 also includes a 24-month requirement to leak test CCWS isolation boundaries that cannot be tested at power.

The staff reviewed the CCWS leak-tightness capability and found it acceptable since CCWS system leak rate was adequately described at 3,028 liters (800 gallons) over seven days, which takes into account pump seals, valve packing, and valve seat leakage. The design normal flow rate of surge tank make-up water is 284 liters per minute (75 gpm), which is more than adequate to compensate for the worst case seat leakage, which assumes simultaneous leakage of all leakage pathways at the boundary with the non-seismic category piping. In addition, TS SR requires system boundary testing every 92 days and once every 24 months. The 92 days TS surveillances will ensure the CCWS system remains operable between refueling cycles.

To provide additional capability for long-term functionality after a SSE, makeup to each CCWS surge tank can be provided by the FSS using piping to the CCWS surge tank makeup connection that is designed to remain functional after an SSE. The supply to the FSS makeup connection is through seismically qualified piping from a seismically qualified water source, as discussed in Section 9.5.1.2.2. Strainers are provided in piping connecting makeup water sources to the surge tank; based on HX flow passage dimensions, the strainer mesh size is 3 mm (0.118 inches).

DCD Tier 2 Section 9.2.1.2.2.3, states that the design of CCWS HXs will incorporate specific features regarding industry operating experience as discussed in EPRI Topical Report 1013470, "Plant Support Engineering: Guidance for Replacing HXs at Nuclear Power Plants with Plate HXs, July 2006," to minimize leakage from plate type HXs and potential blockage of the HX flow passages.

The staff finds that due to the design tolerance of the CCWS plate type HXs, special design features such as filter/strainers are necessary to prevent CCWS HX fouling due to debris in the makeup water to the CCWS surge tank. Since the CCWS design provide strainer of 3 mm (0.118 inches) for all of the CCWS surge tanks makeup sources, there are no concerns related to HX fouling. In addition, due to the leak-tightness of the CCWS boundary, CCWS surge tank makeup is not expected for seven days post DBA.

Conclusion:

Based on the preceding discussion, the staff concludes that the CCWS meets the requirements of GDC 44, which includes the requirements for the transfer of heat from SSCs important to safety to a heat sink during both normal and accident conditions assuming a single failure.

GDC 45

DCD Tier 2 Section 9.2.2.1 states that the CCWS is designed to meet the relevant requirements of GDC 45, periodic inspections of important components. One example of meeting this requirement is described in DCD Tier 2 Section 9.2.2.2.1.3, which states that for the CCWS surge tanks, where one tank is shared between two trains, the CCWS surge tank internal partition plate is accessible for inspection.

DCD Tier 2 Section 9.2.2.2, states that the CCWS is designed so that periodic inspections of piping and components can be performed.

DCD Tier 2 Section 9.2.2.4.2, “In- Service Testing and Inspection,” which references Section 3.9.6, “Functional Design, Qualification, and Inservice Testing Programs for Pumps, Valves, and Dynamic Restraints”; Section 6.2.4, “Containment Isolation Systems”; and Section 6.6, “Inservice Inspection of Class 2 and 3 Components,” adequately describe the inspection details.

Section 3.9.6, 6.2.4 and 6.6 of this SE further describes these sections.

The staff finds sufficient provisions have been established to conclude that reasonable assurance of compliance with GDC 45 exists.

GDC 46

DCD Tier 2 Section 9.2.2.1 states that the CCWS is designed to meet the relevant requirements of GDC 46. In addition, Section 9.2.2.4.2, states that periodic pressure and functional testing of components will be performed to assure the structural and leak tight integrity of system components. Pumps and valves are inspected in accordance with Section XI of the ASME code.

During normal operation, the standby pump and CCWS HX are periodically tested for operability or, alternatively, placed in service in place of the train that has been operating. Routinely during plant shutdown, automatically operated pumps and valves are tested in accordance with SR 3.7.7.4.and SR 3.7.7.5. Additionally periodic flow testing is performed to verify correct flow balancing among individual heat loads.

Normally, a minimum of two trains of CCWS operate continuously in all plant operating modes. These pumps are periodically tested in accordance with plant TS. The system is located in accessible areas to permit in-service inspection as required.

The staff finds sufficient provisions have been established to conclude that reasonable assurance of compliance with GDC 46 exists.

10 CFR 20.1406 “Minimization of Contamination”

10 CFR 20.1406 requires, in part, that applicants for standard plant DCs describe how the facility design and procedures for operation will minimize, to the extent practicable, contamination of the facility and the environment, as well as the generation of radioactive waste.

DCD Tier 2 Section 9.2.2.1.2, states that the CCWS serves as an intermediate system between components containing radioactive fluids, which are cooled by the system, and the ESWS so as to prevent direct leakage of radioactive fluid into the environment through the ESWS.

DCD Tier 2, Section 9.2.2.5.2, states that radiation monitors are located downstream of the supply headers and the signal is indicated in the MCR. When the signal exceeds the setpoint, an alarm is transmitted and the CCWS surge tank vent valve is closed.

DCD Tier 2, Section 9.2.2.2.1.5, states that two MOVs are located at the CCWS outlet of the RCP thermal barrier HX and close automatically upon a high flow rate signal at the outlet of this line in the event of in-leakage from the RCS through the thermal barrier HX, and prevents this in-leakage from further contaminating the CCWS. The MOVs receive a separate signal from each flow device. When the valves receive a high flow signal, the valves are closed. The high flow signal must occur for a duration that is sufficient to assure that a spurious signal does not unnecessarily close the valves. The valves are redundant to assure isolation in the event of a single failure.

The staff concludes that there is no direct path for release of radioactive materials from the CCWS to the environment. In addition, CCWS radiation monitors are provided to alert the operators in case of a leak, thereby providing the opportunity for location and isolation of the faulted equipment. Also, an unexpected increase in surge tank level, for example from a breached RCP thermal barrier, provides another indication of a leak into the CCWS.

In the event that there is in-leakage through the RCP thermal barrier HX, the isolation valves on the RCP thermal barrier HX CCWS return lines are automatically closed by the high flow rate signal, thereby preventing CCWS contamination. Since the probability of contamination in CCWS is very low and the isolation valves are rapidly closed when the in-leakage occurs, potential contamination of the CCWS is minimal. In addition, the isolation valves between the RB and Turbine Building (TB) (or AB), can be closed manually when contamination is detected by radiation monitors.

DCD Tier 2, Section 9.2.2.2.1.3, states that CCWS surge tank makeup water can be supplied from the DWS, PMWS or FSS. The staff concludes that these water makeup sources are normally not contaminated.

The staff finds sufficient provisions have been established to conclude that reasonable assurance of compliance with 10 CFR 20.1406 exists..

9.2.2.4.2 Technical Specifications

DCD Tier 2 Chapter 16, TS 3.7.7, “Component Cooling Water (CCW) System,” provides LCOs and SR for the CCWS. TS 3.7.7 requires three of four CCW trains to be operable in Modes 1, 2, 3 and 4. There is a 72 hour LCO entry if fewer than three CCWS trains are operable.

Since the CCWS surge tanks do not have safety related water makeup to support seven days of operations post DBA, TS SR 3.7.7.2 requires periodic (92 days) verification that leakage for each CCWS train is less than 11.4 L/hr (3.0 gal/hr). If leakage is above this limit, that CCWS train and the associated train for the common header will be declared inoperable if the associated train is not already out of service. TS SR 3.7.7.3 requires verification that the total system leakage of the CCWS valving used to isolate nonsafety piping is less than 94.6 liters (25 gallon) per seven days. This surveillance is required every 24 months.

The staff has evaluated the US-APWR non standard TS for CCWS (TS 3.7.7), which includes the CCWS system leakage and finds the TS for the CCWS have been adequately addressed and finds them acceptable. For CCWS system leakage, the TS SR is adequate to ensure

CCWS system operability given degraded conditions such as valve seat leakage, valve packing leakage and pump seal leakage is within the 7 day capacity of the CCWS surge tank. FSS is provided as a defense in depth water markup to the CCWS surge tank post 7 days DBA and is not addressed in TS.

Chapter 16 of this SE also addresses the staff's evaluation of the CCWS to assure that the proposed LCOs and associated Bases adequately address and reflect system-specific design considerations as described in Section 9.2.2.

9.2.2.4.3 Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC)

DCD Tier 1 Section 2.7.3.3, "Component Cooling Water System," provides US-APWR DC information and ITAAC for the CCWS. Tier 1 information for balance-of-plant SSCs is evaluated in Section 14.3.7 of this SE, and evaluation of the Tier 1 information in this section is an extension of the evaluation provided in Section 14.3.7 of this SE. This evaluation pertains to plant systems aspects of the proposed Tier 1 information for CCWS. The staff reviewed DCD Tier 1, Table 2.7.3.3-1, Table 2.7.3.3-2, Table 2.7.3.3-3, Table 2.7.3.3-4, Table 2.7.3.3-5 and Figure 2.7.3.3-1.

Important aspects of the CCWS design include the significant safety-related functions. Each division provides cooling water for a safety injection pump, a CS/RHR pump and other safety-related components shown in Figure 2.7.3.3-1. Header tie lines between train A and B and between train C and D are provided. A common line for supply header A1 and supply header A2 branches out from the tie line between train A and B. Similarly, a common line for the supply header C1 and the supply header C2 branches out from the tie line between train C and D. The supply headers A1 and C1 provide cooling water for charging pumps, SFP HXs, and other safety-related components shown in Figure 2.7.3.3-1. The supply headers A2 and C2 provide cooling water for the instrument air system and other non safety-related components shown in Figure 2.7.3.3-1. The CCWS line is connected to the Non-ECWS to provide alternate cooling water to the containment fan cooler units.

The staff reviewed the descriptive information, safety-related functions, arrangement, mechanical, I&C and electric power design features, environmental qualification, as well as system and equipment performance requirements provided in DCD Tier 1, Section 2.7.3.3, to confirm completeness and consistency with the plant design basis as described in DCD Tier 2, Section 9.2.2.

Important acceptance criteria related to the CCWS include functional arrangements, physical separation, ASME Code Data reports, ASME welding, ASME pressure testing, seismic classifications, equipment qualification for harsh environment, 1E power, electrical separation, CCWS HX performance, surge tank sizing, CCWS pump flow, CCWS NPSH, CCWS component flow rates, valve testing, system alarms, controls and displays.

The staff finds that all the necessary CCWS equipment has been adequately identified in the applicable tables. The staff concludes that, if the ITAAC for CCWS are performed and the acceptance criteria met, there is reasonable assurance that the design is built and will operate in accordance with the DC, the provision of the Atomic Energy Act of 1954, and NRC regulations which include 10 CFR 52.47(b)(1).

9.2.2.4.4 Initial Test Program

Applicants for standard plant design approval must provide plans for preoperational testing and initial operations in accordance with 10 CFR 50.34(b)(6)(iii), “Contents of applications; technical information,” requirements. DCD Tier 2, Section 14.2.12.1.87, describes the initial test program for the CCWS. Section 14.2 of this SE addresses the staff’s evaluation of the initial test program for US-APWR.

9.2.2.5 Combined License Information or Activities (COL) Items

There are two COL Information Items identified by the applicant related to the CCWS.

> The COL Applicant is to develop a milestone schedule for implementation of the emergency operating procedures to assure that the necessary header tie line isolation valves are closed within 24 hours after an event to achieve train separation (COL Information Item 13.5(6)).
>
> The COL Applicant is to develop a milestone schedule for implementation of the operating and maintenance procedures for water hammer prevention. The procedures should address the operating and maintenance procedures for adequate measures to avoid water hammer due to a voided line condition (COL Information Item 9.2(27)).

No additional COL information items were identified that should be in Table 1.8-2 of the DCD.

9.2.2.6 Conclusions

The staff evaluated the CCWS for the US-APWR standard plant design in accordance with the guidance that is referred to in the Regulatory Basis Section 9.2.2.3 of this SE. The staff’s review included information in the DCD as supplemented by the applicant’s response to numerous RAI which have been incorporated in Interim Revision 4 of the DCD used for this SE.

The staff finds that the applicant appropriately identified heat load and flow requirements for individual safety-related components as well as for the system as a whole in various relevant modes of operation. The staff finds that the US-APWR four safety-related train design with a minimum of two trains required provides inherent tolerance to single failures.

The staff review also included the CCWS ITAAC, pre-operational testing, and TS and the staff finds that these sections provided reasonable assurance that the CCWS will be inspected, tested and operated in accordance with the CCW system design basis.

Based on the review summarized above, pending the resolution of open item discussed above to GDC 2, and the close out of one (1) outstanding **Confirmatory Item** (Interim Revision 4), the staff concluded that the CCWS design is consistent with the guidance of NUREG-0800 SRP 9.2.2 and that the information provided by the applicant adequately demonstrates that the requirements of 10 CFR Part 50, Appendix A, GDCs 2, 4, 5, 44, 45, 46, and 10 CFR 20.1406 are met. In addition, the staff concludes that if the ITAAC for CCWS are performed and the acceptance criteria met, there is reasonable assurance the facility is built and will operate in accordance with the DC, the provision of the Atomic Energy Act of 1954, and the NRC’s regulations which includes 10 CFR 52.47 (b)(1).

9.2.4 Potable and Sanitary Water Systems

9.2.4.1 Introduction

The potable and sanitary water system (PSWS) design consists of a potable water system and a sanitary drainage system. The PSWS provides potable water and sanitary drainage services to various buildings for the US-APWR DCD.

DCD Revision 3 revised the previous Revision 2 of the DCD and for the most part, the PSWS became “conceptual design,” with the exception of the backflow prevention devices for the potable water system.

9.2.4.2 Summary of Application

DCD Tier 1/ITAAC: Section 2.7.6.12 states that the PSWS does not require ITAAC.

DCD Tier 2: Section 9.2.4 describes the PSWS, which includes the DCD Tier 2, Figure 9.2.4-1, “Potable and Sanitary Water System Flow Diagram,” and major component data is provided in Table 9.2.4-1, “Potable and Sanitary Water System Component Data.”

TS: There are no TS for this area of review.

9.2.4.3 Regulatory Basis

The relevant requirements of NRC regulations for this area of review, and the associated acceptance criteria, are given in 10 CFR 52.47, “Contents of application; technical information,” and in NUREG-0800, Section 9.2.4, “Potable and Sanitary Water Systems,” Revision 3, and in 10 CFR Part 50, Appendix A. This includes:

1. 10 CFR 52.47(a)(24), Contents of applications: technical information, requires the inclusion of a representative conceptual design for those portions of the plant that are not included within the scope of the certified design.
2. 10 CFR 52.47(a)(25), requires the identification of interface requirements that must be met by those portions of the plant that are not included within the scope of the certified design.
3. 10 CFR Part 50, Appendix A, GDC 60, “Control of Releases of Radioactive Materials to the Environment,” which relates to design provisions provided to control the release of liquid effluents containing radioactive material from contaminating the PSWS. As part of GDC 60 acceptance criteria, 10 CFR 20.1406, “Minimization of Contamination,” will also be considered.
4. 10 CFR 52.47(b)(1), which requires that a DCAcontain the proposed ITAAC.

9.2.4.4 Technical Evaluation

The US-APWR Final Safety Analysis Report (FSAR) Revision 3 describes the potable and sanitary water system (PSWS) with regard to its ability to provide potable water for domestic use and human consumption and its ability to collect site sanitary waste for treatment, dilution, and discharge. The PSWS is not a safety-related system as DCD Tier 2 Table 3.2-2, “Classification of Mechanical and Fluid Systems, Components, and Equipment.” The US-APWR DCD describes the PSWS as conceptual design with the exceptions of where this potential for contamination exists; the potable water system is protected by installing a backflow prevention device.

The PSWS conceptual design consists of a potable water system and a sanitary drainage system. The PSWS provides potable water and sanitary drainage services to the turbine building (TB), RB, auxiliary building (A/B), access building (AC/B), firehouse, as well as other future facilities.

The potable water system conceptual design consists of a water storage tank with a capacity of 94635.3 liters (25,000 gallons), two motor-driven potable water pumps, a jockey pump, hot water heaters, and a distribution loop that includes a network of piping and valves. The potable water pumps maintain adequate pressure within the distribution system, and are controlled by means of a pressure transmitter located downstream of these pumps. Continuous operation of the jockey pump ensures that system pressure is maintained during periods of low-flow.

The FSAR states that potable water conceptual design is supplied by means of onsite wells, though the source of water is subject to change by the COL applicant. Potable water is chemically treated such that it conforms to the requirements of the Environmental Protection Agency “National Primary Drinking Water Standards,” 40 CFR Part 141. A sodium hypochlorite injection system is used for disinfection. Potable water distribution complies with the “Occupational Safety and Health Standard,” 29 CFR 1910.141, “Sanitation.” Adherence to all state and local environmental protection standards also will be met.

The sanitary drainage system conceptual design collects liquid waste generated in various plant areas, including restrooms and locker rooms. Drainage is routed to individual sump-lift stations that are equipped with sewerage grinder transport pumps that discharge to a treatment facility. The sanitary drainage system does not serve any facilities in the radiologically controlled areas.

Backflow prevention devices (not part of the conceptual design) are used to protect those portions of the potable water system that supply users in areas where the potential exists for radioactive contamination.

The potable water system conceptual design does not make any interconnections between the potable water system and any system using water for purposes other than domestic water service, including any potentially radioactive system. Air gaps are used to separate the potable water supply from other sources supplying water to potentially radioactive systems. The sanitary drainage system conceptual design does not serve any radiological controlled areas and has no interconnections with systems or equipment having the potential for containing radioactive material.

The staff does not perform a GDC 60 or 10 CFR 20.1406 evaluation on any part of the PSWS conceptual design; however, for those sections that are not conceptual design, the staff finds that the design satisfies GDC 60 and 10 CFR 20.1406, as it relates to design provisions for controlling the release of water containing radioactive material and preventing contamination of the potable water.

There are no tests in FSAR Tier 2, Section 14.2, “Initial Plant Test Program,” that relate to the PSWS, although in FSAR Section 9.2.4.4, “Inspection and Testing Requirements,” the applicant lists tests to be performed, including a hydrostatic test of the system. The proposed testing was reviewed by the staff and found to be an acceptable means to verify the system will perform as stated in FSAR Section 9.2.4.

The staff concludes that the PSWS conceptual design satisfies 10 CFR 52.47(a)(24) which requires the inclusion of a representative conceptual design for those portions of the plant that are not included within the scope of the certified design. In addition, the requirements of 10 CFR 52.47(a)(25) have been satisfied by identifying interface requirements that must be met by those portions of the plant that are not included within the scope of the certified design. In this case, the PSWS does not perform a safety function and is not needed for achieving safe shutdown; therefore, there is no Tier 1 interface requirement.

ITAAC: FSAR Tier 1, Section 2.7.6.12, states that the PSWS does not require ITAAC. The staff reviewed this section against the guidance in SRP 14.3.7, "Plant Systems - Inspections, Tests, Analyses, and Acceptance Criteria," and agrees that it is adequate for the PSWS. In addition, the PSWS is not addressed in Tier 1 and is not considered a safety significant system; therefore, Section 3.0, "Interface Requirements," does not address the PSWS.

TS: There are no US-APWR TS sections for the PSWS. The staff finds this aspect of the FSAR acceptable.

9.2.4.5 Combined License Information

The following is a list of COL information items listed in FSAR Tier 2, Section 9.2.10, "Combined License Information."

U.S APWR COL Information Items	
Item No.	Description
COL 9.2(9)	*The COL Applicant is to confirm the storage capacity and usage of the potable water.*
COL 9.2(10)	*COL Applicant is to confirm that all State and Local Department of Health of Natural Resources Environmental Protection Standards are applied and followed.*
COL 9.2(11)	*The COL Applicant is to identify the potable water supply and describe the system operation.*
COL 9.2(12)	*The COL Applicant is to confirm that the sanitary waste is sent to the onsite plant treatment area or they will use the city sewage system.*
COL 9.2(14)	*The COL Applicant is to confirm Table 9.2.4-1 for required components and their values.*
COL 9.2(15)	*The COL Applicant is to determine the total number of people at the site and identify the usage capacity. Based on these numbers the COL Applicant is to size the potable water tank and associated pumps.*
COL 9.2(17)	*The COL Applicant is to determine the total number of sanitary lift stations and is to size the appropriate interfaces.*

9.2.4.6 Conclusion

Based on the review above, the staff determined that adequate design provisions have been made to prevent the inadvertent contamination of the PSWS with radioactive material. The staff concludes that the applicant has adequately described the PSWS to the level of detail to determine if Tier 1 interface requirements are required.

The staff concludes, related to the design that is non-conceptual, that the design of the PSWS is acceptable and it meets the requirements of GDC 60 and 10 CFR 20.1406 because there are no interconnections between the PSWS and any contamination systems. In addition, the non-conceptual design portion of the PSWS does not require ITAAC; therefore, the 10 CFR 52.47(b)(1) requirements have been satisfied.

9.2.5 Ultimate Heat Sink

9.2.5.1 Introduction

The UHS consists of an assured source of water with associated safety-related structures designed to dissipate the heat rejected from the ESWS during normal and accident conditions. It also provides NPSH to the ESWS. The UHS is not part of the standard plant design and therefore the details of the design provided as part of this DCD application are considered CDI. However the UHS standard plant design does identify some non-CDI requirements that all applicants referencing this design shall incorporate or provide an appropriate departure for the staff to review. In addition, the UHS standard plant design outlines COL items and interface requirements for COL Applicants.

9.2.5.2 Summary of Application

DCD Tier 1: The UHS is addressed in Tier 1, Section 2.7.3.3, “Essential Service Water System,” since the UHS is a site-specific interface with the ESWS. There are no function arrangement figures or tables since the UHS is CDI. In addition, there are no ITAACs for the UHS in the DCD. Section 3.2.1 lists the UHS interface requirements. COL Applicants must meet these interface requirements using a detailed design and must also generate site-specific ITAAC for each interface requirement. These site-specific ITAAC will be in addition to any other ITAAC already committed to by the DCD.

DCD Tier 2: The UHS is also addressed by DCD Tier 2, Section 9.2.5. Figure 9.2.5-1 “Ultimate Heat Sink Flow Diagram”; Table 9.2.5-1 “UHS Peak Heat Loads”; Table 9.2.5-2 “UHS Heat Load for LOCA and Safe Shutdown with LOOP”; Table 9.2.5-3 “UHS System Design Data”; and Table 9.2.5-4, “Failure Modes and Effects Analysis for the UHS,” provide sufficient CDI to identify applicable interface requirements. A very small amount of the information provided in these sections is part of the standard plant design to be evaluated in this report. DCD Chapter 9.2.10 identifies UHS COL items.

ITAAC: There are no ITAAC for the UHS since it is not part of the standard plant design.

TS: TS for the UHS are provided by DCD Tier 2, Section 16 TS 3.7.9. Discussion of this TS as it relates to the UHS, may be found in Section 9.2.5.4 of this SE.

9.2.5.3 Regulatory Bases

The relevant requirements of the NRC Regulations for this area of review, and the associated acceptance criteria are given in SRP Section 9.2.5 of NUREG-0800, Revision 4 issued March 2007. Review interfaces with other SRP sections can be found in Section 9.2.5 of NUREG-0800. However, since this portion of the DCD is not part of the standard plant design, these regulatory bases and associated GDC will be evaluated when site specific applications are reviewed. The remaining requirements for portions of the DCD that are not part of the standard plant design are as follows:

10 CFR 52.47(a)(24), which requires that a DCA contain a representative conceptual design for those portions of the plant for which the application does not seek certification, to aid the NRC in

its review of the DCD and to permit assessment of the adequacy of the interface requirements in paragraph (a)(25) of this section.

10 CFR 52.47(a)(25), which requires that a DCA contain interface requirements to be met by those portions of the plant for which the application does not seek certification. These requirements must be sufficiently detailed to allow completion of the DCD.

10 CFR 20.1406, “Minimization of Contamination,” as it relates to the standard plant DCs and how the design and procedures for operation will minimize contamination of the facility and the environment facilitate eventual decommissioning and minimize to the extent practicable, the generation of radioactive waste.

9.2.5.4 Technical Evaluation

The staff evaluation of the UHS is based upon the information provided by the applicant in a October 14, 2011 letter, “Markup for US-APWR DCD Section 9.2,” which transmitted DCD Tier 2, Section 9.2.5, Interim Revision 4. This letter also provided DCD markups for other Tier 1 and DCD Tier 2, Sections applicable to the review of DCD Tier 2, Section 9.2.5.

For UHS, the staff requested that the applicant respond to questions in 10 RAIs that were based on the information in DCD Revisions 0, 1, 2 and 3 that described the design, operation, and testing of the UHS. The applicant answered these questions in numerous responses that included DCD markups, which the staff reviewed and finds acceptable. In a letter dated October 14, 2011, the applicant provided the DCD Interim Revision 4 markup for the applicable DCD sections. The staff reviewed the response and confirmed that the DCD Interim Revision 4 markup, dated October 14, 2011, contains all of the relevant UHS RAI responses. In this SE, the staff is not describing each staff RAI and applicant response. The staff’s technical evaluation is based on review of the DCD Interim Revision 4 markup for the applicable sections. In some cases, RAI responses are discussed where clarifying information was not described in the DCD markup. To ensure that DCD Interim Revision 4 markup information is incorporated in the latest revision of the DCD, the October 14, 2011, letter is being tracked as Confirmatory Item.

9.2.5.4.1 Standard Plant Design

DCD Tier 2 Chapter 9.2.5 describes design details of the UHS that are both part of the standard plant design and conceptual design. Those portions that are CDI are placed inside brackets [X]. Below is an evaluation of the standard plant design information not inside brackets.

The UHS operates in conjunction with the ESWS. The ESWS is described in Section 9.2.1. The UHS is designed to meet GDC 2, 4, 5, 44, 45, and 46 and in accordance with RG 1.27. Site specific designs will address these regulations. The UHS is safety-related and supports the four separate and redundant divisions of the ESWS. The UHS will be able to dissipate the maximum total heat load from the ESWS under normal and accident condition, including that of a LOCA or safe shutdown scenario with LOOP under the worst combination of adverse environmental conditions, even freezing, and cool the unit for a minimum of 30 days (or minimum of 36 days for cooling pond) without makeup water. The water inventory also assures the available NPSH at the lowest expected water level for the ESW pumps at the end of the 30-day emergency cooling period. The peak heat loads are shown in DCD Tier 2, Table 9.2.5-1 for safe shutdown and LOCA conditions. The decay heat is estimated using ANSI/ANS 5.1, “Decay Heat Power for Light Water Reactors.” The UHS will provide suitable component redundancy such that the system's safety functions can be performed in the event of a single active component failure, coincident with an accident such as a LOCA and safe shutdown with LOOP under extreme meteorological conditions, using either offsite power or onsite emergency power sources.

The UHS is designed for a single nuclear power unit and is not shared between units. The maximum UHS water temperature to ESWS is 95 ºF. The safety-related structures and components of the UHS are designed to equipment Class 3 and Seismic Category I requirements to remain functional during and following an SSE.

The COL Applicant is to design the UHS based on specific site conditions and meteorological data (COL Information Item 9.2(18)). The COL Applicant is to design the UHS to receive its electrical power supply, if required by the UHS design, from safety buses so that the safety functions are maintained during LOOP (COL Information Item 9.2(19)). The COL Applicant is to provide a detailed description and drawings of the UHS, including water inventory, temperature limits, heat rejection capabilities under limiting conditions, instrumentation, and alarms (COL Information Item 9.2(20)). The COL Applicant is to determine [the normal source of makeup water to the UHS inventory and the blowdown discharge location] which are in operation at any time before the start of the 30-day emergency cooling during an accident or safe shutdown with LOOP. The [blowdown] discharge is provided as a check point for monitoring and neutralizing chemistry of ESW discharges to the environment (COL Information Item 9.2(21)). The COL Applicant is to determine source and location of the UHS (COL Information Item 9.2(3)). The COL Applicant is to determine location and design of the ESW intake structure (COL Information Item 9.2(4)). The COL Applicant is to determine location and design of the ESW discharge structure (COL Information Item 9.2(5)).

Each ESWP takes suction from its UHS located beneath the pump house as described in Section 9.2.5.2.1. The water flows through the CCW HXs and essential chiller units then back to the UHS. Low and high water level are annunciated in the MCR. The maintained water level in each UHS assures adequate NPSH for the ESWP under all operating modes. The ESWS together with the UHS are designed, arranged and operated to minimize the effects of water hammer forces. The system layout assures water pressure remains above saturation conditions throughout the system. High point vents and low point drains are provided. A more detailed discussion of water hammer can be found in Section 9.2.1 of this SE as it relates to the ESWS.

The LOOP sequence actuation signal automatically starts the Class 1E GTGs to resume power to any active components in each UHS train during LOOP events. The wet bulb design temperature is based on climatological data in accordance with RG 1.27. The COL Applicant will provide results of UHS capability and safety evaluation of the UHS based on specific site conditions and meteorological data per RG 1.27 (COL Information Item 9.2(22)).

The COL Applicant will provide test and inspection details based on the type of UHS to be provided. These details will include inspection and testing requirements necessary to demonstrate that fouling and degradation mechanisms are adequately managed to maintain acceptable UHS performance and integrity (COL Information Item 9.2(23)). Periodic inspections and tests of UHS and ESWS components and subsystems are performed to verify proper operation and system operability. This includes ASME Section XI requirements as discussed in Section 6.6. The COL Applicant is to develop maintenance and test procedures to monitor debris build up and flush out debris (COL Information Item 9.2(26)). The COL Applicant will provide the required alarms, instrumentation and controls details based on the type of UHS to be provided (COL Information Item 9.2(24)). Alarms and displays are provided in the MCR and RSC for the following parameters:

- UHS Water Level - MCR/RSC display, high level alarm and low level alarm.
- UHS Water Temperature (ESW supply) - MCR/RSC display, high temperature alarm and low temperature alarm.

The staff finds that this standard plant design provided, along with the numerous COL items, provides an adequate description of what criteria a site specific UHS design should meet. Based on information provided, the staff concludes that there is reasonable assurance that a safety-related UHS can be designed to meet the regulatory bases described in SRP 9.2.5 and RG 1.27 and will evaluate future site specific designs using that basis.

9.2.5.4.2 10 CFR 20.1406 "Minimization of Contamination"

10 CFR 20.1406 requires, in part, that applicants for standard plant DCs describe how the facility design and procedures for operation will minimize, to the extent practicable, contamination of the facility and the environment, as well as the generation of radioactive waste.

DCD Tier 2 Section 9.2.5.2.1, describes that the path for radioactive fluid to reach the UHS must pass through two barriers the CCWS and the ESWS. CCWS plate HXs are constructed to prevent intermixing of fluids so that leakage from radioactive fluid will go outside of the HX and not into the CCWS. In addition, radiation alarms on the CCWS side of the HXs are provided to alert operators of contamination in the CCWS. The affected CCWS train can be immediately isolated followed by the isolation of the aligned ESWS to prevent possible contamination of the UHS and the environment. Further, there is a radiation monitor in the ESWS for added capability in monitoring for potential radiation leakage. Therefore, the staff finds that additional radiation monitoring of the UHS is not needed and normal sampling is sufficient.

The staff finds sufficient provisions have been established to conclude that reasonable assurance of compliance with 10 CFR 20.1406 exists.

9.2.5.4.3 Technical Specifications

DCD Tier 2 Chapter 16, TS 3.7.9, "Ultimate Heat Sink," provides LCOs and SR for the UHS. TS 3.7.9 requires three of four UHS trains to be operable in Modes 1, 2, 3 and 4. There is a 72 hour LCO entry if fewer than three UHS trains are operable.

Since the UHS is mostly CDI, there are only two standard plant design operating limits that apply to all COL Applicants minimum UHS usable water capacity (both for volume and NPSH for ESWS pumps) and maximum UHS initial water temperature. All additional site specific UHS TS will be evaluated based on COL Applicant submittals.

Chapter 16 of this SE also addresses the staff's evaluation of the UHS to assure that the proposed LCOs and associated Bases adequately address and reflect system-specific design considerations as described in Section 9.2.5.

9.2.5.4.4 Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) and Interface Requirements

DCD Tier 1 Section 2.7.3.1, “Essential Service Water System,” provides US-APWR DC information for the UHS since the two systems interface. Tier 1 information for balance of plant SSCs is evaluated in Section 14.3.7 of this SE, and evaluation of the Tier 1 information in this section is an extension of the evaluation provided in Section 14.3.7 of this report. This evaluation pertains to plant systems aspects of the proposed Tier 1 information for UHS. There are no ITAAC for the UHS as the design is mostly CDI.

Section 3.2.1 lists the UHS interface requirements. COL Applicants must meet these interface requirements using a detailed design and must also generate site-specific ITAAC for each interface requirement. The interface requirements are:

- The UHS system design meets the divisional separation requirements of the ESWS and the UHS is capable of performing its safety functions under design basis event conditions and coincident single failure with or without offsite power available.
- The safety related, pressure retaining components, and their supports, are designed, constructed and inspected in accordance with ASME Code Section III, if applicable to the site-specific design.
- The maximum supply water temperature is 95 °F under the peak heat loads condition to provide sufficient cooling capacity to ESWS.
- The UHS water level is maintained such that available NPSH is greater than the ESW pump's required NPSH during all plant operating conditions including normal plant operations, abnormal and accident conditions. The ESW pump operation does not cause vortex formation at minimum allowed UHS water level.
- The UHS system has MCR and RSC alarms and displays for UHS water level and water temperature.
- The UHS system has MCR and RSC controls for UHS components’ active safety functions if applicable to the site-specific design.
- UHS components that have PSMS control (if applicable to the site-specific design) perform an active safety function after receiving a signal from PSMS.
- The UHS can provide the required cooling for a minimum of 30 days without make-up during accident conditions.
- The UHS system is designed to prevent water hammer.

The staff finds that all the necessary UHS interface requirements have been identified using the CDI provided in the DCD. The staff concludes that these interface requirements can be developed into site specific ITAAC for UHS. Thus, the staff finds that the requirements of 10 CFR 52.47(a)(24) and 10 CFR 52.47(a)(25) are met.

9.2.5.4.5 Initial Test Program

Applicants for standard plant design approval must provide plans for preoperational testing and initial operations in accordance with 10 CFR 50.34(b)(6)(iii), “Contents of applications; technical information,” requirements. The UHS supports ESWS operation and is therefore tested as part of the ESWS preoperational test described in Section 14.2.12.1.34. As indicated in Section 14.2.12, the COL Applicant is responsible for testing outside the scope of the certified design. Section 14.2 of this SE addresses the staff’s evaluation of the initial test program for US-APWR.

9.2.5.5 Combined License Information or Activities (COL) Items

There are 10 COL information items identified by the applicant related to the UHS. All of them were evaluated within Section 9.2.5.4 of this SE and the staff finds them adequate. A comprehensive reference list is located in DCD Tier 2 Chapter 9.2.10 with the corresponding item numbers used in this evaluation. No additional COL information items that should be in Table 1.8-2 of the DCD were identified by the staff.

9.2.5.6 Conclusions

The staff’s evaluation of the UHS for the US-APWR standard plant design is in accordance with the guidance that is referred to in the Regulatory Basis Section 9.2.5.3 of this SE. The staff’s review included information in the DCD as supplemented by the applicant’s response to numerous RAI which have been incorporated in Interim Revision 4 of the DCD used for this SE.

The staff’s review finds that the applicant appropriately identified standard plant design requirements for future COL Applicants who reference this design. The CDI provided was not evaluated against GDC or RG 1.27. Site specific COL applications will be evaluated to meet those requirements. The staff finds the UHS COL items to be comprehensive for future COL Applicants. The staff also finds that the UHS standard plant design does meet 10 CFR 20.1406 and concludes that there are sufficient interface requirements to meet 10 CFR 52.47(a)(24) and 10 CFR 52.47(a)(25). The staff finds that the US-APWR four safety-related train designs with a minimum of two trains required, provide inherent tolerance to single failures.

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Based on the review summarized above, and the close out of the outstanding **confirmatory item** (Interim Revision 4), the staff concluded that the UHS design demonstrates that the requirements of 10 CFR 20.1406 and 10 CFR 52.47(a)(24) and 10 CFR 52.47(a)(25) would be met. The staff will evaluate whether the UHS of future COL applications is in accordance with the GDCs and guidance committed to in the standard plant design.

9.2.6 Condensate Storage Facilities

9.2.6.1 Introduction

The condensate storage facilities (CSF) serve as a receiver for excess water generated by other systems – such as the main condenser hotwell, and makeup water treatment system. It also functions as the water supply or makeup source for various auxiliary systems.

9.2.6.2 Summary of Application

DCD Tier 1: There are no Tier 1 entries for this area of review in the US-APWR DCD.

DCD Tier 2: The applicant has provided a Tier 2 system description in Section 9.2.6 of the US-APWR DCD, summarized here in part, as follows:

> The CSF system consists primarily of three systems: (1) demineralized water system, (2) condensate storage and transfer system, and (3) primary makeup water system. The demineralized water system consists of one demineralized water storage tank (DWST), two 100-percent-capacity demineralized water transfer pumps, and associated valves, piping, and instrumentation. The condensate storage and transfer system consists of one condensate storage tank (CST), two 100-percent-capacity condensate transfer pumps, and associated valves, piping and instrumentation. The primary makeup water system consists of two primary makeup water tanks (PMWT), each of 140,000-gallon capacity, two 100-percent-capacity primary makeup water pumps and associated valves, piping, and instrumentation.
>
> The CSF system is shown schematically in Figures 9.2.6-1, 9.2.6-2, and 9.2.6-3. The design parameters of the CSF system main components are shown in Table 9.2.6-1.

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

Technical Specifications: There are no technical specifications for this area of review.

9.2.6.3 Regulatory Basis

The relevant requirements of the Commission’s regulations for this area of review, and the associated acceptance criteria, are given in Section 9.2.6 of NUREG-0800, the SRP, and are summarized below. Review interfaces with other SRP sections can be found in Section 9.2.6.I of NUREG-0800.

1. GDC 2 of Appendix A to 10 CFR Part 50, as related to the system’s capability to withstand the effects of natural phenomena including earthquakes and tornadoes.

2. GDC 5, as related to the capability of shared systems and components to perform required safety functions.

3. GDC 44, as related to ensuring the following:

    a. Redundancy of components so that, under normal and accident conditions, the safety functions can be performed assuming a single active component failure coincident with the loss of offsite power.

    b. The capability to isolate components, subsystems, or piping if required so that the system safety function will not be compromised.

    c. The capability to provide sufficient makeup water to safety-related cooling systems.

4. GDC 45, as related to design provisions to permit inservice inspection of safety-related components and equipment.

5. GDC 46, as related to design provisions that permit pressure and operational functional testing of safety-related systems and components to ensure structural integrity, system leak-tightness, operability and performance of active components, and capability of the

integrated system to function as intended during normal, shutdown, and accident conditions.

6. GDC 60, as it relates to tanks and systems handling radioactive materials in liquids.

7. 10 CFR 50.63, as related to design provisions to support the plant's ability to withstand and recover from a station blackout (SBO).

8. 10 CFR 52.47(b)(1), which requires that a design certification (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, the facility has been constructed and will operate in conformity with the combined license (COL), the provisions of the Atomic Energy Act, and the Nuclear Regulatory Commission's (NRC's) regulations.

9. 10 CFR 20.1406, "Minimization of contamination," as it relates to the design features that will facilitate eventual decommissioning and minimize, to the extent practicable, the contamination of the facility and the environment and the generation of radioactive waste.

9.2.6.4 Technical Evaluation

The staff reviewed Tier 2, Section 9.2.6, "Condensate Storage Facilities,(CSF)," of the US-APWR Design Certification Document (DCD). For the US-APWR, the CSF is nonsafety-related and has no safety-related functions. The safety-related function of assuring that an adequate supply of water is provided to the emergency feedwater system in the event that it is required for safe shutdown of the reactor often performed by the CSF system is accomplished using the emergency feedwater pits in the US-APWR design. The design of the emergency feedwater pits is included in Tier 2, Section 10.4.9 "Emergency Feedwater" of the US-APWR DCD. The staff evaluated the emergency feedwater pits design against Standard Review Plan (SRP) Section 9.2.6. The results of the staff's review of the emergency feedwater pits and their compliance with SRP Section 9.2.6 is included in Section 10.4.9 of this SER. The US-APWR design does not rely on the CSF in response to a Station Blackout (SBO).

The staff reviewed the CSF design in accordance with SRP 9.2.6. Acceptance of the CSF design is based on meeting the relevant requirements of General Design Criteria (GDC) 2, "Design bases for protection against natural phenomena"; 5, "Sharing of structures, systems, and components"; 44, "Cooling water"; 45, "Inspection of cooling water system"; 46, "Testing of cooling water system," 60, "Control of releases of radioactive materials to the environment"; and 10 CFR 20.1406. Because the CSF is not credited with providing water to safety-related cooling systems, is a nonsafety-related system and has no safety-related functions, and the US-APWR application is for a single unit plant, only GDC 2, GDC 60 and 10 CFR 20.1406, are relevant.

A. GDC 2 "Design Bases for Protection Against Natural Phenomena"

The staff reviewed the CSF for compliance with the requirements of GDC 2 with respect to its design for protection against the effects of natural phenomena. Compliance with the requirements of GDC 2 is based on adherence to Position C.2 of Regulatory Guide 1.29, "Seismic Design Classification," since the CSF is a nonsafety-related system.

In DCD Tier 2, Section 9.2.6.2 “System Description,” the applicant states that all system components meet design code requirements consistent with the component quality group and seismic design classification, and that provisions are made for mitigating the environmental effects of system leakage or storage tank failure. However, the applicant did not provide any details on the provisions made to mitigate environmental effects of system leakage and storage tank failures. The staff requested in **RAI 9.2.6-1** that the applicant describe the provisions and design features of the CFS that will be relied on for mitigating the environmental effects of system leakage or storage tank failure.

The applicant responded to RAI Question 9.2.6-1 in a letter dated February 5, 2009. In its response the applicant stated that the demineralized water storage tank (DWST), condensate storage tank (CST), and primary makeup water tanks (PMWTs) are nonsafety-related and non-seismic, and that failure of their structural integrity would not impact on Seismic Category I structures, systems and components (SSCs) or cause adverse system interactions. The applicant also stated that a dike is provided for the PMWTs and the CST for mitigating the environmental effects of system leakage or storage tank failure. In addition, DCD Tier 2, Section 3.4.1.2 provided additional information about flood protection from external sources such as outside storage tanks. Since the system has no safety-related functions, and provisions have been made to collect and control contents of the CST in the event of a system leak, tank overflow or tank rupture, and because structural failure of the system will not affect the ability of safety-related SSCs to perform their intended function, the staff finds the design to be in conformance with the guidelines of Regulatory Position C.2 of RG 1.29, and with the requirements of GDC 2. The applicant provided as part of its RAI response a markup showing proposed revisions to the DCD. The staff has reviewed the revision and finds it acceptable; therefore RAI 9.2.6-1 is resolved. The staff verified that the proposed markup was added to the Revision 2 of the FSAR, and the RAI is considered closed.

B. GDC 60 “Control of Releases of Radioactive Materials to the Environment”

The staff reviewed the design of the CSF for compliance with the requirements of GDC 60 with respect to control of releases of radioactive materials. According to SRP 9.2.6 Section III, Item 3.E, condensate tank overflow should be connected to the radwaste system. GDC 60 requires that a means be provided to control the release of radioactive materials in liquid effluents. However, the applicant did not provide any discussion related to the routing of overflow from the CSF. Accordingly, in **RAI 9.2.6-2**, the staff requested the applicant to describe how the CSF complies with GDC 60 and SRP Section 9.2.6, Item 3.E.

The applicant responded to RAI Question 9.2.6-2 in a letter dated February 5, 2009. In its response the applicant stated the CST is located outdoors, and is in compliance with GDC 60, a dike is provided which is capable of preventing runoff if the tank overflows or fails. The staff has reviewed the applicant response and finds that it does not resolve the staff’s concern. In addition to preventing runoff if the tank overflows or fails, SRP Section 9.2.6, Item 3.E also indicates that condensate storage overflow piping should be connected to the radwaste system, and that for nonsafety-related storage facilities, the need for a Seismic Category I dike or retention basin should be reviewed. The applicant’s RAI response failed to discuss how the condensate storage overflow is connected to the radwaste system and did not identify the dike as being seismically designed. The response also failed to address any radioactive monitoring associated with the system. Based on its review the staff asked in **RAI 9.2.6-2** that the applicant address the above concerns related to radwaste system connection, the seismic design of the dike, and the radioactive monitoring of the CSF.

The applicant provided additional information to address RAI 9.2.6-2 in a letter dated June 09, 2009. In the first of three parts of the response the applicant explained that the CST overflow will be retained by the dike, and then can be routed to the turbine building sump, which is monitored for radiation. If radioactivity is detected in the sump, an alarm is activated in the Main Control Room (MCR) and the sump is pumped to the liquid waste management system (LWMS) for processing. The staff finds that this method of routing CST overflow to the LWMS is acceptable and it meets the guidance specified in RG 1.143.

In the second part of the response the applicant responded to the staff's questions related to monitoring for level and potential radioactivity in the CST. According to DCD section 9.2.6.5.2, the CST level is monitored and indicated locally and in the MCR. Alarms are provided in the MCR for both high and low level. Regarding radioactivity, the applicant states that it is not expected that there would be a significant level of radiation in the liquid from the CST. In the event of a CST overflow, radioactive liquid would be detected in the turbine building sump and routed to the LWMS for processing as described above. The staff finds that the level of instrumentation provided is acceptable for monitoring the CST as it conforms to the guidance of RG 1.143.

The third part of the RAI response addresses the staff's concern about the seismic classification of the CST dike. The applicant states that the dike is installed to prevent release of radioactive liquid in the case of CST overflow or failure and that it is designed in accordance with RG 1.143. The staff agrees that RG 1.143 guidelines are appropriate design standards for this application of the dike; however, upon review of the DCD the staff could not locate the specific indication that the CST dike is designed in accordance with RG 1.143. Instead, the staff found that in DCD Table 1.9.2-9 "US-APWR Conformance with Standard Review Plan Chapter 9 Auxiliary Systems," the applicant indicates that SRP Section 9.2.6 does not apply to the US-APWR design. Item 6 in that table provides guidance stating that for control of radioactive releases to the environment, meeting relevant aspects of GDC 60 is based on meeting the guidance of RG 1.143. As previously indicated, GDC 2 and GDC 60 are applicable to the US-APWR CSF design. Therefore the staff issued **RAI 9.2.6-3** to request that this information be included in Section 9.2.6 of the DCD, and that DCD Table 1.9.2-9, be revised to accurately reflect the applicability of SRP Section 9.2.6 to the US-APWR design. **RAI 9.2.6-3 is being tracked as an open item. (Open Item 9.2.6-3)**

C. 10 CFR 20.1406 "Minimization of Contamination"

10 CFR 20.1406 requires in part that each design certification applicant describe how the facility design and procedures for operation will minimize, to the extent practicable, contamination of the facility and the environment, as well as the generation of radioactive waste. In DCD Section 9.2.6 the applicant states that " the condensate storage and transfer system and primary makeup water system of the condensate storage facility are subject to the design objectives of R.G. 4.21, "Minimization of Contamination and Radioactive Waste Generation : Life-Cycle Planning."

The CSF transfer piping between the CST and the hotwell is single-walled, welded, stainless steel piping in a coated trench with removable covers. The design is subject to periodic hydrostatic or pressure testing of pipe segments, instrument calibration and, when required, visual inspection and maintenance of piping, trench and instrument integrity.

The piping to and from the primary makeup water storage tank is single-walled, welded, stainless steel piping designed to run above ground and penetrates the building wall directly into the tank. For piping between buildings, penetration sleeves are provided to collect and direct any leakage back into the building for further processing. The design is subject to operational programs, which include periodic hydrostatic or pressure testing of pipe segments and visual inspection to maintain piping integrity.

Based on the above, the staff concludes that the CSF design, as described in the US-APWR DCD, is in compliance with 10 CFR 20.1406, “Minimization of contamination,” since the CSF is designed such that (1) the system piping will be accessible for inspection and maintenance, so that, if leaks occur in the system, the leaks can be readily identified and corrective actions can be taken, and (2) CST overflow is directed to the condensate storage tank sump inside the dike area; thus, CSF fluids are prevented from being released to the environment unmonitored.

Based on the above review, and pending resolution of **Open Item 9.2.6-3,** the staff finds that CSF design satisfies the guidance of SRP 9.2.6 including the GDC relevant to this design (GDC 2 and GDC 60) and 10 CFR 20.1406.

Technical Specifications: There are no US-APWR Technical Specification sections for the CSF. The staff finds this aspect of the FSAR acceptable.

9.2.6.5 Combined License Information

In accordance with DCD Tier 2 Table 1.8-2 and DCD Tier 2 Sections 9.2.6, the applicant has not identified any COL information items that are directly applicable to the CFS. No additional COL items that should be in Tier 2, DCD Table 1.8-2 were identified by the staff.

9.2.6.6 Conclusion

Pending resolution of Open Item 9.2.6-3, the design of the CSF in FSAR Tier 2, Section 9.2.6, is acceptable, because, as set forth above, it meets appropriate regulatory requirements including GDC 2 on protection from natural phenomena, and GDC 60 for control of release of radioactive material to the environment, and 10 CFR 20.1406 for Minimization of Contamination.

9.2.7 Chilled Water System

9.2.7.1 Introduction

The chilled water system encompasses two independent closed loop systems, which are the ECWS and the non-essential chilled water system (non-ECWS).

The ECWS is safety related and consists of four independent divisions (Division A, B, C & D) with each division providing fifty percent (50 percent) of cooling capacity required for design basis accidents and for safe shutdown. Each division consists of a water-cooled chiller, a chilled water pump, a compression tank with a make-up water line (Demineralized or PMWS), a chilled water distribution loop, and instrumentation and control system. The condenser (heat rejection) section of each chiller is supplied with cooling water from the respective ESWS during both normal and emergency operating conditions.

The function of the ECWS is to provide, during normal and emergency conditions, a heat sink for various safety related air handling units (AHU) that are located in the PS/B (east and west) and the RB. AHUs that are cooled by the ECWS include those in the penetration area, annulus emergency exhaust filtration unit area, MCR, safeguard component area, Class 1E electrical room, emergency feedwater pump area, CCW pump area, essential chiller unit area and charging pump area. The ECWS rejects the heat from these AHUs to the essential chiller units. Heat from the essential chiller units is rejected to the ESWS.

The non-ECWS system is non-safety related, with the exception of the portions of the system that penetrate containment and the associated valves. The non-ECWS system consists of four divisions consisting of water-cooled chillers, four chilled water pumps, a compression tank with a make-up water line (Demineralized or Primary makeup water system), a chilled water distribution loop, and an I&C system. The condenser (heat rejection) section of each chiller is supplied with cooling water from a dedicated cooling tower. Each chiller is sized for one-third of the total non-essential chilled water load.

The function of the non-ECWS is to provide, during plant normal operation and LOOP, a heat sink for various non-safety related AHUs. These AHUs include those in the Technical Support Center (TSC), A/B, and non-Class IE electrical rooms. While the non-ECWS is a non-safety related system, the non-ECWS containment penetrations, penetration isolation valves and interconnecting piping are safety-related and designed to seismic Category I specifications.

9.2.7.2 Summary of Application

Tier 1 FSAR: The ECWS is addressed in Tier 1 FSAR, Section 2.7.3.5, “Essential Chilled water System (ECWS),” and Figure 2.7.3.5-1, Sheets 1 to 2. The non-ECWS is addressed in Tier 1 FSAR, Section 2.7.3.6, “Non-Essential Chilled water System (non-ECWS)”.

Tier 2 FSAR: The chilled water system (ECWS and non-ECWS) is addressed in Tier 2 FSAR, Section 9.2.7, “Chilled Water System,” and Figure 9.2.7-1, “Essential Chilled Water System Flow Diagram,” and Figure 9.2.7-2, “Non-Essential Chilled Water System Flow Diagram,” Initial plant testing for the chilled water system is described in Tier 2 FSAR, Section 14.2.12.1.60 (ECWS) and Section 14.2.12.1.104 (non-ECWS).

ITAAC: ITAAC for the chilled water system are included in Tier 1 FSAR, Table 2.7.3.5-5 (ECWS) and Table 2.7.3.6-3 (non-ECWS).

9.2.7.3 Regulatory Basis

The relevant requirements of the Commission Regulations for this area of review, and the associated acceptance criteria are given in SRP Section 9.2.2 of NUREG-0800, Revision 4 issued March 2007, and are summarized below.

GDC 2, “Design Bases for Protection against Natural Phenomena,” as related to structures housing the system and the system itself having the capability of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes and floods without loss of safety-related functions.

GDC 4, “Environmental and Dynamic Effects Design Bases,” as to effects of missiles inside and outside of containment, pipe whip, jets, and environmental conditions from high and moderate energy line breaks and dynamic effects of flow instabilities and loads (e.g., water hammer) during normal plant operation, as well as during accident conditions.

GDC 5, “Sharing of Structures, Systems and Components,” requires that that SSCs which are important to safety shall not be shared among nuclear power units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions including, in the event of an accident in one unit, an orderly shutdown and cooldown of the remaining units.

GDC 44, “Cooling Water,” as it relates to requirements for the transfer of heat from SSCs important to safety to a heat sink during both normal and accident conditions assuming a single failure.

GDC 45, “Inspection of Cooling Water System,” as it relates to design provisions for appropriate periodic inspection of important components, such as HX and piping, to assure continued system integrity and functional capability.

GDC 46, “Testing of Cooling Water Systems,“ requires that the cooling water system shall be designed to permit appropriate pressure and functional testing.

10 CFR 52.47(b)(1), which requires that a 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 facility that incorporates the design certification has been constructed and will be operated in conformity with the DC, the provisions of the Atomic Energy Act of 1954, and NRC’s regulations.

9.2.7.4 Technical Evaluation

The staff’s evaluation of the chilled water system is based upon the information provided in the DCD, as described in Tier 2 Section 9.2.7 and in other sections of the DCD as referred to below. The ECWS is shown in Tier 2 Figure 9.2.7-1 and the non-ECWS is shown in Tier 2 Figure 9.2.7-2. DCD Tier 1 Sections 2.7.3.5 and 2.7.3.6 describe ECWS and non-ECWS respectively.

9.2.7.4.1 System Design Considerations

For chilled water systems (ECWS and non-ECWS), the staff asked the applicant numerous RAIs (RAI 343-2208 and RAI 584-4468) regarding the design, operation, and testing of the chilled water system which were based on the information in Revisions 0, 1, and 2 of the FSAR. The applicant responded to these questions in numerous RAI responses that included FSAR markups which the staff reviewed. In its letter dated July 17, 2009 (MHI’s Responses to US-APWR DCD RAI 343-2208, Revision 0, MHI Ref: UAP-HF-09350), the applicant provided responses to Question 09.02.02-1 through Question 09.02.02-21. In its letter dated July 15, 2011 (Amended MHI’s Response to US-APWR DCD RAI 584-4468, Revision 0, MHI Ref: UAP-HF-11217), the applicant responded to the issues in RAI 584-4468, Question 09.02.02-70 through Question 09.02.02-79 (MHI Ref: UAP-HF-10167). In its letter dated July 29, 2011 (Markup for US-APWR Section 9.2.2, MHI Ref: UAP-HF-11242), the applicant provided an interim Revision 4 of the FSAR that incorporates all the proposed changes noted in RAI 584-4468, Question 09.02.02-70 through Question 09.02.02-79. In this SE, the staff is not describing each staff RAI and the information the applicant provided in response to each RAI; rather, the staff’s technical evaluation below is based on the staff’s review of the interim FSAR Revision 4 that is included in the letter dated July 29, 2011 (Markup for US-APWR Section 9.2.2, MHI Ref: UAP-HF-11242), for the applicable sections, which includes all the pertinent information submitted in response to the original RAIs.

As indicated in Section 9.2.7.1.1 of the DCD, the ECWS is designed to meet the relevant requirements of GDC 2, GDC 4, GDC 44, GDC 45, and GDC 46.

A. GDC 2, "Design Bases for Protection against Natural Phenomena"

In accordance with GDC 2 requirements, the chilled water system must be capable of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods without loss of capability to perform its safety functions with and without off-site power available. Analyses, design features, and provisions that are credited for satisfying GDC 2 requirements are described in the Tier 2, Chapter 3 sections that address the specific hazards considerations, and the staff's evaluation of these analyses, design features, and provisions are provided in the corresponding Chapter 3 sections of this SE.

All of the major ECWS equipment and components are located within the Seismic Category I RB and PS/B. Therefore, the integrity and operability is assured during all natural phenomena. The major non-safety components of non-ECWS are located in the AB. To confirm protection of safety related SSCs in the event of failure of non-safety portions of piping, RAI 584-4468, Question 09.02.02-70 was generated to clarify that piping of the non-ECWS within an area containing safety related equipment is designed adequately. In response to this RAI and as indicated in Table 3.2-2, "Classification of Mechanical and Fluid System, Components, and Equipment," the piping of the non-ECWS within an area containing safety-related equipment is designed as seismic Category II.

Tier 2, DCD Section 3.2 specifies the classification of SSCs based on safety importance and other considerations. The staff's evaluation of the classification designations that are specified is provided in Section 3.2 of this SE, and this section of the staff's evaluation confirms that the appropriate classification designations are specified for the two chilled water systems consistent with the approach that is described in Tier 2, DCD Section 3.2.

Based on the criteria specified in Tier 2, DCD Section 3.2, essential parts of the ECWS should be designated as safety-related, seismic Category I, Quality Group C and controlled in accordance with 10 CFR 50 Appendix B requirements. Similarly, the essential parts of the non-ECWS related to containment penetrations should be designated as safety-related, seismic Category I, Quality Group B and controlled in accordance with 10 CFR 50 Appendix B requirements. Parts of the non-ECWS that are non-safety related are designated with an equipment class of 9, non-seismic. The staff confirmed that this information is correctly reflected in Tier 2, DCD Table 3.2-2, Item numbers 45 (ECWS) and 46 (non-ECWS) and that 10 CFR Appendix B requirements are appropriately specified for the safety-related parts of the system. It is important to isolate the safety and non-safety systems to avoid the possibility of failure of the non-safety system from adversely affecting the safety related portions of the system. The staff confirmed that Figure 9.2.7-1 and Figure 9.2.7-2 clearly indicate the physical separation between each division and indicate required classification changes.

As discussed above, the staff has confirmed that the safety and non-safety related portions of the chilled water system are properly classified such that the evaluation in Chapter 3 will ensure that the chilled water system is capable of performing its safety functions during natural phenomena. Also, because each of the safety-related chilled water system divisions has its own safety-related emergency power source, which is protected from the effects of natural phenomena as evaluated in Chapter 3, the LOOP as a result of natural phenomena will not adversely affect the capability of the chilled water system to perform its safety functions.

Aside from confirming that the safety related and non-safety related parts of the chilled water system are properly classified, the staff reviewed the chilled water system for potential vulnerabilities to natural phenomena that may not be adequately addressed by the design features and provisions that are credited in Chapter 3. The staff issued **RAI 343-2208, Question 09.02.02-05** requesting the applicant to fully describe parts of the system that are necessary to assure the capability of the chilled water system to perform its safety functions during natural phenomena.

In a letter dated July 17, 2009 (MHI's Responses to US-APWR DCD RAI 343-2208 Revision 0, MHI Ref: UAP-HF-09350) the applicant, in response to RAI 343-2208, Question 09.02.02-05, provided a description of non-safety and safety-related interfaces of the chilled water system.

The ECWS contains connections to non-safety related support systems such as; the compressed gas supply system (CGS), the PMWS, DWS and the chemical feed tank. System makeup water and nitrogen supply from CGS are provided in each division with control valves to adjust flow. Check valves are used to isolate the ECWS from the non-seismic support systems and prevent the loss of pressure or water within the system due to a failure of control valves. The control valves are designed as non-safety related, seismic Category II and the check valves are designed as Seismic Category I, Quality Group C. Therefore, ECWS integrity and operability is assured by these support system check valves. In addition, the non-safety, Seismic Category II essential chilled water chemical feed tank and connecting piping is isolated from the safety related ECWS with the use of normally locked closed valves.

The non-ECWS includes a connection to the CCWS to allow chilled water use as alternate cooling for the charging pumps in the event of the failure of CCWS during severe accident conditions. As indicated in Section 9.2.2.2 of the DCD, at the boundary of the non-ECWS and the CCWS, there are redundant normally-closed MOVs to isolate systems.

In addition, the CCWS can be used as an alternative supply of cooling water to the containment fan coolers of the non-ECWS in the event of severe accident. In order to provide isolation between the seismic Category I CCWS and the non-seismic non-ECWS, two locked-closed valves are provided as indicated in Section 9.2.2.2 of the DCD. Therefore, CCW system integrity and operability is assured by these isolation valves.

DCD Tier 2 Section 9.2.7.1.1.1 and 9.2.7.1.2.1 indicates that the ECWS and non-ECWS are in compliance with GDC 2 and commits to meeting the guidance of RG 1.29. The applicable sections of RG 1.29 include Position C.1 for safety related portions and Position C.2 for non-safety related portions. The applicant's description of the design and interactions between the safety and non-safety related sections of the ECWS and non-ECW are acceptable, as they address the functioning of chilled water system safety and non-safety related boundaries to ensure integrity and operability during seismic event.

Based on the above and by virtue of the ECWS location within protective buildings and a Seismic Category I structure that protects against flood and tornado missiles, the chilled water system complies with GDC 2 with regard to protection against natural phenomena. In addition, the safety-related portion of non-ECWS in the RB and PS/B is similarly protected.

B. GDC-4, "Environmental and Dynamic Effects Design Bases"

The chilled water system must be adequately protected from dynamic effects due to equipment failures and external environmental conditions and must be capable of performing its safety functions over the entire range of environmental conditions that are possible in accordance with GDC 4 requirements. Analyses, design features, and provisions that are credited for satisfying GDC 4 requirements are described primarily in Tier 2, DCD Sections 3.6 and 3.11, and the staff's evaluations of these analyses, design features, and provisions are provided in the corresponding sections of this SE.

The staff reviewed the ECWS and non-ECWS to determine if the design meets the relevant requirements of GDC 4. Section 3.6.1 of this SE addresses the staff's evaluation of the design of structures, shields, and barriers necessary for SSCs to be protected against dynamic effects of high-energy line breaks. Based on the staff's evaluation discussed in Section 3.6.1 of this SE, the staff finds that the ECWS is protected against the effects of, and is compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents.

The ECWS consists of four independent divisions (Division A, B, C & D) with each division providing fifty percent (50 percent) of cooling capacity required for design basis accidents and for safe shutdown. As indicated above, the major portion of the independent divisions are located in separate PS/B buildings. The ECWS is designed to perform its safety function with only two out of four divisions operating. The ECWS divisions are completely separate and a single failure does not compromise the system's safety function even if one division is out of service for maintenance. MHI performed a failure analysis of the ECWS system and presented the results in the Table 9.2.7-3 to demonstrate that failure of a single active component (chiller unit or pump) will render a division inoperable but not compromise the ability of the system to perform its function.

The major components of the non-ECWS are located in the AB and on the roof of the AB. Therefore, failure of any of these components will not adversely affect safety-related SSCs. In addition, the piping of the non-ECWS within an area containing safety-related equipment is designed as seismic Category II. Safety-related portions of the system are located such that the adverse consequences of a pipe or other component failure will not prevent the safety-related portions of the system from performing their safety function.

The ECWS is designed in consideration of the water hammer prevention and mitigation guidance as discussed in NUREG-0927 and described below:

- A compression tank to keep the system filled.
- Vents for venting components and piping at all high points in the system.
- After any system drainage, venting is assured by personnel training and procedures.
- System valves are slow acting.

The DCD contains a COL item to assure that the COL Applicant is to develop a milestone schedule for implementation of the operating and maintenance procedures for water hammer prevention. The procedures should address the plant operating and maintenance procedures for adequate measures to avoid water hammer due to a voided line condition.

The non-essential chilled water system includes containment penetrations in order to provide chilled water to the control rod drive mechanisms (CRDM) cooling unit and containment fan cooler which are located inside the containment vessel. The containment vessel penetrations and isolation valve configuration are shown in Tier 2, DCD Figure 6.2.4-1, "Containment

Isolation Configurations," and described in Table 6.2.4-3, "List of Containment Penetrations and System Isolation Positions." The review of containment isolation system is located in Section 6.2.4 of this SE.

Based on the capacity, physical separation, and redundancy between each ECWS division, failure of a single division will not jeopardize the capability of performing its safety function. From the evaluation above and the assessment of system reliability in accordance with GDC 44 below, the staff finds that the system design complies with GDC 4 regarding capability to continue functioning to ensure safe shutdown during normal operations, anticipated operational occurrences (AOOs), and accident conditions. In addition, as reviewed in Section 3, the ECWS is designed to be able to prevent or mitigate the consequences of an accident caused by exposure to environmental conditions of normal operations, maintenance, testing, or postulated accidents.

C. GDC 5, "Sharing of Structures, Systems, and Components"

The US-APWR standard plant design is a single-unit station. Therefore, the requirements of GDC 5 are not applicable to the US-APWR standard plant design.

D. GDC 44, "Cooling Water"

In accordance with GDC 44 requirements, the ECWS shall have the capability to transfer heat loads from safety related SSCs to the heat sink under normal operating and accident conditions, providing suitable redundancy for components given a single active failure, and the capability to isolate part of the system so that the safety function is not compromised. The chilled water system is comprised of two independent closed loop systems, the ECWS and non-ECWS.

The safety related ECWS provides a heat sink for various safety related AHUs which are located in the PS/B (east and west) and the RB. The nonsafety-related non-ECWS provides a heat sink for various non-safety related AHUs; however, the piping system penetrates the containment vessel. The staff evaluated descriptive information, heat transfer and flow requirements, single failure, NPSH and compression tank design to ensure the chilled water system is capable of performing its functions in accordance with this requirement.

The staff reviewed the chilled water system description and flow diagram and found that the flow paths and components have been identified and described in sufficient detail to enable a full understanding of the system design and operation, including a clear distinction between safety-related and non-safety related parts of the system.

Non-ECWS system design:

During plant normal operating conditions, three non-essential chilled water pumps and three non-essential chiller units, including dedicated cooling towers and condenser pumps, are operated. The additional train of equipment is placed in standby. In the event of LOOP conditions, only two non-essential chilled water pumps and two non-essential chiller units are powered from the permanent non-safety power distribution system and are actuated automatically to protect property and assets, but not for nuclear safety. In the event of a LOCA, the non-ECWS is not required and containment isolation valves are automatically closed upon receipt of the containment isolation signal.

Makeup water to the non-ECWS system is supplied by the PMWS, and the DWS which, in turn, receives water from the Raw Water System. The PMWS and DWS systems are evaluated in Sections 9.2.6 of this SE.

The non-ECWS is non safety-related, except for the portions of the system that penetrate containment and the associated valves. Non-ECWS is not required to ensure (1) integrity of the RCS pressure boundary, (2) capability to achieve and maintain safe shutdown, or (3) the ability to prevent or mitigate OREs during accidents. Therefore, GDC 44, 45, and 46, identified as acceptance criteria in SRP Section 9.2.2 do not apply to the non-safety-related portion of the non-ECWS system. However, the system is provided with instrumentation, temperature and pressure indicating devices to facilitate testing and verification of equipment heat transfer capability and flow blockage. The non-ECWS does contain safety related penetrations that are subject to the requirements of GDC 44.

The non-ECWS system is routed to the containment through two penetrations: one for the supply line and the other for the return line. The supply line penetration has one motor-operated isolation valve outside the containment and a check (isolation) valve inside the containment. The return line penetration has two motor-operated isolation valves, one inside and one outside the containment. Isolation valves and piping for the containment penetrations are safety-related and are designed to seismic Category I, Quality Group B, and 10 CFR 50, Appendix B, standards. The penetrations and isolation valve configurations are reviewed in Section 6.2.4 of this document. The description of the testing of containment isolation valves is provided in Chapter 6, Section 6.2.4, Containment Isolation System (applicable to non-essential chilled water system containment isolation valves). Based on this information and the details provided in Section 6, the staff concludes that the safety-related portions of the non-ECWS meet the requirements of GDC 44 regarding the provision for reliable systems for transferring heat loads to a heat sink.

As indicated above, the non-ECWS has the capability to isolate components, systems, or piping by use of normally closed CCW valves so that system safety functions of the interconnected CCW are not compromised.

The non-ECWS system includes pumps, chillers, valves and piping, surge tank, makeup piping, and the points of connection or interfaces with other systems. The staff reviewed the FSAR design criteria, design bases, and safety classification for the ECWS system against the requirements for supplying adequate cooling water for auxiliary equipment for all conditions of plant operation. The staff concludes, as discussed above, that the design of the non-ECWS, “non- Essential Chilled Water System”, system is acceptable and meets the applicable requirements of GDC 2, 4, 5, 45, and 46, and the guidelines of SRP Section 9.2.2.

ECWS system design

The ECWS is safety-related and provides a heat sink for various safety-related AHUs, which are located in the PS/B (east and west) and the RB, and must be capable of performing its safety function during normal operating and accident conditions over the life of the plant.

As described above, the ECWS consists of four independent divisions (A, B, C, D) and each division consists of a 50 percent capacity system. ECWS divisions A and B are located in the east PS/B and divisions C and D are located in the west PS/B. There is no interconnection between the ECWS divisions and divisional separation which provides assurance that a failure will affect no more than one division. Each of the four independent divisions contains a water-cooled chiller, a chilled water pump, a compression tank with a make-up water line, a chilled water distribution loop, and I&C system. The condenser (heat rejection) section of each chiller is supplied with cooling water from the respective ESWS during both normal and emergency operating conditions.

During normal operation, two divisions of ECWS are in service, with a total of two essential chilled water pumps and two essential chiller units in operation. An operating essential chilled water pump supplies chilled water to cooling coils of safety-related HVAC systems throughout the chiller units. The chiller units and pumps that are not in service are placed in standby. In the event that a required chiller unit malfunctions or trips, a standby chiller unit can be manually placed in service from the MCR or RSC. The chiller unit includes a start permissive that ensures that chilled water and condenser water flows are established prior to the operation of the chiller unit. The system includes I&Cs for monitoring and controlling system parameters, such as chilled water flow and temperature, and compression tank pressure. Since the system is not expected to contain any significant level of radioactivity, it has no radiation monitors.

Table 9.2.7-1, “Essential Chilled Water System Component Design Data,” provides the design characteristics for the system components (e.g., capacity of the ECWS refrigeration units, chilled water pump flow rate, chilled water and condenser water supply temperatures). Table 9.2.7-2, “Essential Chilled Water System Heat Load and Flow Rate,” specifies the heat removal and flow requirements for the individual system components. This information indicates that two divisions of the system are capable of rejecting the total heat from the components the system serves.

In the event of a LOCA, four essential chilled water pumps and four essential chiller units are actuated automatically upon receipt of the ECCS actuation signal, and are loaded onto their respective Class 1E power source. As a minimum, two trains are required to operate during a LOCA. In the event of a LOOP, four essential chilled water pumps and four essential chiller units are powered from the emergency power source and they are actuated automatically by the LOOP load sequence signal. As a minimum, two trains are required to operate during a LOOP.

As specified in Tier 2, DCD Table 9.2.7-1, the evaporation capacity of each of the four safety related ECWS chillers is designed as 3.6 x 10^6 Btu/hr-unit with pump flow rates at 1,666 liters per minute (440 gpm) and a differential temperature across the evaporators of 8.6 °C (16 °F). The cooling requirements of safety related HVAC components along with the heat loads for normal and abnormal accident conditions are shown in Table 9.2.7-2.

The ECWS is sized to achieve heat transfer and flow requirements for normal and abnormal conditions as shown in Table 9.2.7-2, based on the heat loads served under the worst-case conditions. Further discussion of the basis of ECWS component sizing and margin is described in response to RAI 584-4468, Question 09.02.02-72. As shown in Figure 9.2.7-1, each independent ECWS division (A, B, C, and D) contains an essential chilled water pump that can be controlled manually from the MCR with a pressure indication at the inlet and outlet to confirm operability. The ECWS pump sends water into the chiller unit at a temperature of at least 13.3 °C (56 °F) and returns chilled water at a temperature of 4.4 °C (40 °F) which provides cooling for the safety related AHU areas. The ECWS divisions C and D, provide cooling to additional non-safety related spaces (refer to DCD Figure 9.4.5-2) in the Class 1E Electrical Rooms, which are not heat loads for divisions A and B. As such, the Class 1E Electrical Room AHU heat load for divisions C and D is 2,290,000 Btu/hr each, whereas the heat load for divisions A and B is 1,650,000 Btu/hr each. The higher heat load is conservatively used for the heat removal capability sizing for each of the ECWS divisions. Water chemistry control is performed by adding chemicals to the chemical feed tank to prevent long term corrosion that may degrade system performance.

In addition, DCD Section 9.2.7.2.1, specifies a 10 percent margin is added to pump head and NPSH, and ECWS pumps are designed in consideration of the fluctuation in electrical frequency, pipe roughness, and maximum pressure drop through the system.

The compression tank capacity is designed with sufficient water for at least seven days of operation in the event of a loss of makeup water taking into account minor leakage. As indicated in RAI 584-4468, Question 09.02.02-74, the tank capacity includes margin in the volume requirement to accommodate the minor system leakages since the tank capacity is double the required volume for thermal expansion and contraction alone. Leakage is not normally expected from the ECWS and accommodating significant amounts of volume loss is not the intent of the compression tank design. Major leakage from a pipe failure, pump seal failure, or other significant source would constitute a division failure, and the redundant division would provide the heat removal function. Deaerated water from the primary makeup system provides the initial system fill for the ECWS. As indicated in response to RAI 584-4468, Question 09.02.02-73, make-up to the ECWS is from the DWS and no dissolved gas in the system fluid is expected from these water sources. Although the compression tank is pressurized with nitrogen, there is no flow through the tank and the volume of fluid out of the tank during thermal contraction is not significant, relative to the volume of the system. Therefore, even with an assumption of nitrogen saturated water within the tank, there is no potential for dissolved gas to affect pump performance.

Motor-operated three-way control valves are located on the return lines from each safety-related AHU cooling coil to control heat removal capacity by modulating the flow of chilled water through the AHU cooling coils. The water temperature entering and leaving the chiller is indicated in the MCR and is alarmed with abnormal chiller unit condition. Pressure of the system is maintained by the use of nitrogen supply into the ECWS compression tank with an indication and alarm in MCR to alert the operator of an abnormal condition. The compression tank makeup water control valve modulates supply of demineralized makeup water so that the tank level is maintained within a pre-set range. The compression tank nitrogen gas supply valve is controlled with open-closed control so that the tank pressure is maintained within a pre-set range.

The ECWS must be capable of performing its safety functions assuming a single failure with and without off-site power available. As indicated above, only two ECWS 50 percent divisions are needed for accident mitigation and the four division ECWS design provides complete redundancy. As a result, the system is capable of performing its safety function with failure of one division with another division out of service for maintenance. All four ECWS divisions are powered by a Class 1E power source and are backed by SBO gas turbines (AAC-GTC). Upon a LOOP, each ECWS division receives power from its respective emergency power source. As indicated above, the applicant has performed a failure analysis of the ECWS and presented the results in Table 9.2.7-3 of the DCD to demonstrate that failure of a single active component will not compromise the ability of the system to perform its function.

Based on the review above, the ECWS is designed with the capability to transfer heat loads from the SSC to the heat sink under both normal and accident conditions. In addition, the design of the ECWS includes sufficient separation and independence for both mechanical and electrical components of the redundant divisions and protection for the system to perform its function under all reactor conditions, including a LOCA, loss of normal ac power, or a single active component failure in the system. On the basis of the above discussion, the staff finds that the ECWS complies with the requirements of GDC 44.

E. GDC 45, "Inspection of Cooling Water System" and GDC 46, "Testing of Cooling Water System"

The non-ECWS system is not safety-related because it is not required to ensure (1) the integrity of the RCS pressure boundary, (2) the capability to achieve and maintain safe shutdown, or (3) the ability to prevent or mitigate OREs during accidents. Therefore, GDCs 45, and 46, identified as acceptance criteria in SRP Section 9.2.2 do not apply to the nonsafety-related portion of the non-ECWS system.

The performance, structural, and leak-tight integrity of system components is demonstrated by operation of the system. Preoperational testing is described in Chapter 14, entitled "Initial Test Program and ITAAC." Chillers and chilled water pumps are hydrostatically tested in accordance with ASME Section III. The system is provided with adequate instrumentation, temperature and pressure indicating devices to facilitate the testing and verification of the equipment heat transfer capability and flow blockage. Local display devices indicate vital parameters required in testing and inspections. For example, chilled water flow rate and temperature of the system can be checked by viewing the display of locally-mounted pressure and temperature gauges at the main control panel. The DCD states that during normal operation, the standby trains are periodically tested for operability or, alternatively, placed in service in place of the train that has been operating.

As indicated in the DCD, the essential and non-essential chilled water systems provide accessibility for adjustment, periodic inspection, and maintenance activities to assure continuous functional reliability.

The staff finds that the design of the system complies with the requirements of GDC 45 and 46 for inspection and testing of safety-related cooling water systems.

9.2.7.4.2 Technical Specifications

The US-APWR does not include any TS for the ECWS or non-ECWS. This is consistent with SRP Section 16, NUREG-1431, "Standard Technical Specifications for Westinghouse Plants," and is acceptable to the staff. Further review of US-APWR TS is located in Section 16 of this document.

9.2.7.4.3 Tier 1 and Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC)

Tier 1, DCD Section 2.7.3.6, "Non-Essential Chilled Water System (non-ECWS)," provides US-APWR DC information and ITAAC for the non-ECWS. The ITAAC associated with the non-ECWS equipment, components, and piping that comprise a portion of the Containment Isolation System (CIS) are described and reviewed in Section 2.11.2 and Table 2.11.2-2

Tier 1, DCD Section 2.7.3.5, "Essential Chilled Water System (ECWS)," provides US-APWR DC information and ITAAC for the ECWS. The Tier 1 ITAAC information is evaluated in the applicable portion in Section 14.3 of this SE, and evaluation of the Tier 1 information in this section is an extension of the evaluation provided in Section 14.3. This evaluation pertains to plant systems aspects of the proposed Tier 1 information for ECWS.

The staff reviewed the descriptive information, safety related functions, arrangement, mechanical, I&C and electric power design features, environmental qualification as well as system and equipment performance requirements provided in Tier 1 FSAR, Section 2.7.3.5, to confirm completeness and consistency with the plant design basis as described in Tier 2 FSAR, Section 9.2.7. The staff also reviewed Table 2.7.3.5-1, “Essential Chilled Water System location of Equipment and Piping,” Table 2.7.3.5-2, “Essential Chilled Water System Equipment Characteristics,” Table 2.7.3.5-3, “Essential Chilled Water System Piping Characteristics,” Table 2.7.3.5-4, “Essential Chilled Water System Equipment Alarms, Displays, and Control Functions,” Table 2.7.3.5-5, “Essential Chilled Water System Inspection, Tests, Analyses, and Acceptance Criteria,” and Figure 2.7.3.5-1, “Essential Chilled Water System.”

Tier 1 of the DCD includes the following ITAAC:

- ECWS pumps have sufficient NPSH.
- Confirm functional arrangement.
- Verify separation of redundant divisions (physical separation and Class 1E redundancy), verify seismic Category I components.
- Verification of ASME code Section III components.
- Verify pressure boundary welds.
- Verify that the ECWS removes heat from various cooling coils during all plant operating conditions, including normal plant operating, abnormal and accident conditions.
- Alarms and displays are provided in the MCR and the RSC and perform as designed.
- The ECWS compression tank volume accommodates system thermal expansion and contraction, and seven day system operation without make-up.

The staff finds that all the necessary ECWS equipment has been adequately identified in the applicable tables. The staff concludes that if the ITAACs for ECWS are performed and the acceptance criteria met, there is reasonable assurance that the facility is built and will operate in accordance with the DC, the provision of the Atomic Energy Act of 1954, and the NRC’s regulations which includes 10 CFR 52.47 (b)(1).

9.2.7.4.4 Initial Test Program

Tier 2, DCD Section 14.2.12.1.60, “Essential Chilled Water System Preoperational Test,” describes the initial test program for the ECWS. In addition, Tier 2, DCD Section 14.2.12.1.104, “Non-Essential Chilled Water System Preoperational Test,” describes the initial test program for the non-ECWS. The initial test program for the US-APWR is evaluated in Section 14.2 of this SE.

The objective of the ECWS initial test program was found to be appropriate since it is to demonstrate the capability of the ECWS to provide the required flow to components during both normal and emergency conditions. The results of the ECWS test program are considered to be acceptable if the ECWS perform as described in Tier 2, DCD Section 9.2.7.

9.2.7.5 Combined License Information or Activities (COL) Items

As indicated in Section 9.2.7.2.1 and COL Information Item 9.2(27), the COL Applicant is to develop a milestone schedule for implementation of the operating and maintenance procedures for water hammer prevention. The procedures should address the plant operating and maintenance procedures for adequate measures to avoid water hammer due to a voided line condition.

The above COL item is included in Table 1.8-2, "Compilation of All Combined License Applicant Items for Chapters 1-19," of the DCD. Aside from the above discussed COL items, there are no additional items identified at this time that should be included as new or revised COL items.

9.2.7.6 Conclusions

The staff evaluated the chilled water system for the US-APWR standard plant design in accordance with the guidance that is referred to in the Regulatory Evaluation Section above. The staff's review included information in the FSAR as supplemented by the applicant's response to numerous RAIs which have been incorporated in Interim Revision 4 of the FSAR used for this SE.

The staff's review finds that the applicant appropriately identified heat load and flow requirements for individual safety-related components as well as for the system as a whole in various relevant modes of operation. The staff finds that the US-APWR four safety-related division design with a minimum of two divisions required, provided inherent tolerance to single failures.

Based on the review summarized above, and the incorporation of interim Revision 4 into the next FSAR submittal**,** the staff concluded that the Chilled Water System design is consistent with the guidance of NUREG-0800, SRP 9.2.2 and that the information provided by the applicant adequately demonstrates that the requirements of 10 CFR Part 50, Appendix A, GDCs 2, 4, 44, 45, 46 would be met.

9.2.8 Turbine Component Cooling Water System

9.2.8.1 Introduction

The turbine component cooling water system (TCS) provides cooling water to remove heat from various TB components such as the generator gas coolers, secondary pump motors, main turbine lube oil coolers, condenser vacuum pumps, and air compressors. The system consists of three 50 percent capacity pumps, three 50 percent capacity plate type HXs, stand pipe, chemical addition tank, associated piping, valves, controls, and instrumentation. Cooling water to the TCS HXs is supplied via the non-ESW system which is further discussed in Section 9.2.9 of this SE. The TCS performs no safety-related functions and is classified non-safety related.

9.2.8.2 Summary of Application

Design control document (DCD) Tier 1: The Tier 1 information associated with this section is found in Tier 1, Section 2.7.3.4, “Turbine Component Cooling Water System,” of the US-APWR DCD, Revision 3.

DCD Tier 2: The applicant has provided a Tier 2 system description in Section 9.2.8 of the DCD Revision 3. Figure 9.2.8-1, “Turbine Component Cooling Water System Piping and Instrumentation Diagram,” shows the TCS configuration. Table 9.2.8-1, “TSC Component Parameters,” describes the TCS pumps and TSC HXs.

ITAAC: The TCS does not require ITAAC, reference DCD Tier 1, Section 2.7.3.4.

TS: There are no TS for this area of review.

9.2.8.3 Regulatory Basis

The staff determined that no current NUREG-0800, SRP section was directly applicable to the TCS. While many specific requirements may not be applicable, in order to facilitate evaluation of DCD Tier 2 Section 9.2.8, the staff selected SRP Section 9.2.1, “Essential Service Water System,” Revision 5, issued March 2007, SRP 9.2.2, “Component Cooling Water,” Revision 3, issued March 2007; and SRP Section 10.4.3, “Turbine Gland Sealing System,” Revision 3, issued March 2007 to be utilized as guidance.

The acceptance criteria contained in the noted SRPs that are of importance related to the TCS include:

1. General Design Criteria (GDC) 2, “Design Basis for Protection Against Natural Phenomena,” as it relates to the capability of the design to maintain and perform its safety function following an earthquake or other natural phenomena. Acceptance for seismic criteria for the cooling water system is based on conformance with Position C.2 of RG 1.29, “Seismic Design Classification,” for non-safety related portions of the TCS.

2. GDC 60,”Control of Releases of Radioactive Materials to the Environment,” as it relates to the control of releases of radioactive materials to the environment. As part of GDC 60 acceptance criteria, 10 CFR 20.1406, “Minimization of Contamination,” will also be considered.

Also, in accordance with 10 CFR 52.47(b)(1), the DC application must include the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the COL, the provisions of the Atomic Energy Act of 1954, and the NRC’s regulations.

9.2.8.4 Technical Evaluation

The staff’s evaluation of the TCS is based upon the information provided in Tier 1 Section 2.7.3.4, and Tier 2 Section 9.2.8, and in other DCD sections as referred to below. The TCS is shown in Tier 2, Figure 9.2.8-1.

9.2.8.4.1 System Design Considerations

A. GDC 2, Design Basis for Protection Against Natural Phenomena

GDC 2 requires that the SSCs which are important to safety to be protected from natural phenomena such as seismic events. In accordance with Tier 2, DCD Table 3.2-2, "Classification of Mechanical and Fluid Systems, Components, and Equipment," Item 50, the TCS has an equipment classification of eight (non-safety, and a NRC Quality Group D), is located in the TB, and has a seismic category of non-seismic (NS).

Based on the staff's review of Tier 2, Table 3.2-4, "Seismic Classification of Buildings and Structures," the TB is classified as Seismic Category II. In addition, the staff determined that there are no safety related SSCs in the TB based on the staff's review of Tier 2, DCD Chapter 3.

The TB is subject to flooding. The bounding flooding source in the TB is the circulating water piping; however, the plant design includes flooding relief system built into the TB wall. The flooding event from the TCS has no safety related implication and is bounded by the circulating water system flooding event and is addressed in Section 10.4.5 of this SE.

In summary, the staff's review finds that sufficient information was provided by the applicant to determine compliance of the applicable portions of the TCS with the requirements of GDC 2, and that Position C.2 of RG 1.29 for non-safety related portions of the TCS has been satisfied. Failure of the TCS will not reduce the function of any SSCs important to safety and could not result in injury to occupants of the control room since there is no safety-related equipment located in the TB.

B. GDC 60, Control of Releases of Radioactive Materials to the Environment and 10 CFR 20.1406.

The staff reviewed the Tier 2 information related to the TCS and based on this review there was no discussion related to the TCS containing radioactivity. Therefore, the staff generated **RAI 252-1968, Question 9.2.2-1,** to address the issue related to control of releases of radioactive materials to the environment in accordance with GDC 60 and the minimization of contamination in accordance with 10 CFR 20.1406.

The applicant responded to **RAI 252-1968, Question 9.2.2-1,** in a letter dated March 30, 2009. The response stated that under normal operating conditions, there are no radioactive contaminants of operational concern present in the TCS. However, it is possible for the TCS to become contaminated in the event of primary to secondary system leakage into the condensate system. When an unacceptable radioactivity level is detected by the radiation monitors, radiation is indicated and alarmed in the MCR, and operating procedures are implemented. These monitors are steam generator (SG) blowdown water radiation monitor, condenser vacuum pump exhaust line radiation monitors, and gland seal system exhaust fan discharge line radiation monitors. These monitors are discussed in Tier 2 DCD Sections 11.5.2.3.5, 11.5.2.4.2, and 11.5.2.4.3, respectively.

The staff evaluated this RAI response and determined that it was unacceptable; therefore, the staff generated **RAI 567-4326, Question 9.2.2-46,** for the applicant to address the following items:

1. Explain how the TCS satisfies the requirements specified by 10 CFR 20.1406, since it is possible for the TCS to become contaminated in the event of a primary to secondary system leakage;

2. Describe why non-contaminated water sources are not preferred for the TSC standpipe makeup. For example, the demineralized water storage tank would be a non-contaminated source.

The applicant responded to **RAI 567-4326, Question 9.2.2-46,** in a letter dated May 7, 2010. For items 1 and 2, the applicant stated that in the interest of 10 CFR 20.1406, the applicant has reconsidered the TCS stand pipe makeup water source and determined that makeup to the TCS stand pipe should be delivered from the DWS tank as shown in Attachment 1 of the response. With this change, the TCS will have no radiological impact. Therefore, the TCS codes and standards as shown in Table 3.2-2 will be revised from 4 to 5 as shown in Attachment 2 of the response.

The staff's review finds this RAI response acceptable since the TCS makeup was changed from a potential radioactive source to a normally non-radioactive water source. The staff reviewed the associated DCD markup and found it acceptable. These DCD markups (Table 3.2-2 and Figure 9.2.6-1) are included in Revision 3 of the DCD; therefore, RAI 252-1968, Question 9.2.2-1 and RAI 567-4326, Question 9.2.2-46 is considered to be closed.

In summary, the staff's review finds that sufficient information was provided by the applicant to determine compliance of the TCS with the requirements of GDC 60 and 10 CFR 20.1406 since the TCS stand pipe makeup water source to the TCS stand pipe is delivered from the DWS tank which is a non-contaminated water source.

9.2.8.4.2 Technical Specifications

DCD Tier 2 Chapter 16, "Technical Specifications," is not applicable to the TCS because there are no TS associated with the TCS.

9.2.8.4.3 Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC)

There are no ITAAC associated with the TCS. Based on a graded approach commensurate with the safety significance of the SSCs, the staff agrees that ITAAC are not required for the TCS since the TCS is a non-safety related system located in the TB, and no safety-related equipment is located in the TB.

9.2.8.4.4 Initial Test Program

Tier 2, Section 14.2.12.1.88, "Turbine Component Cooling Water System Preoperational Test," describes the preoperational test to demonstrate the operation of the TCS prior to initial plant startup. Section 14.2 of this SE further addresses the staff's evaluation of the initial test program for US-APWR DCD.

9.2.8.5 Combined License Information Items (COL)

There are no COLs items identified in Tier 2, DCD. No COL items were identified by the staff that should be in Tier 2, DCD Table 1.8-2.

9.2.8.6 Conclusion

The staff evaluated the TCS US-APWR standard plant design in accordance with the guidance that is referred to in the Regulatory Basis, Section 9.2.8.3 of this SE.

Based on the review summarized above, the staff concludes that the TCS design is consistent with the guidance of NUREG-0800, SRP 9.2.1, SRP 9.2.2 and SRP 10.4.3 and that the information provided by the applicant adequately demonstrates that the requirements of 10 CFR Part 50, Appendix A, GDC 2 and 60, and 10 CFR 20.1406 would be met. In addition, the staff concludes that ITAAC for TCS are not required thus, meets the provision of the Atomic Energy Act of 1954, and the NRC's regulations, which include 10 CFR 52.47 (b)(1).

9.2.9 Non-Essential Service Water System

9.2.9.1 Introduction

The non-essential service water system (non-ESW) provides cooling water to remove heat from the TCS. Cooling water to the non-ESW is supplied via the CWS downstream of the condenser inlet block and the non-ESW is discharged to the circulating water system upstream of the condenser outlet block.

The non-ESW is composed of three 50 percent capacity non-ESW system pumps, three 50 percent capacity TCS HXs, two 100 percent capacity strainers, piping, valves, controls, and instrumentation. The non-ESW system performs no safety-related functions and is classified non-safety related.

TCS, Section 9.2.8, "Turbine Component Cooling Water System," and CWS, Section 10.4.5, "Circulating Water System," are further discussed in this SE.

9.2.9.2 Summary of Application

DCD Tier 1: The Tier 1 information associated with this section is found in Tier 1, Section 2.7.3.2, "Non-Essential Service Water System," of the US-APWR DCD, Revision 3.

DCD Tier 2: The applicant has provided a Tier 2 system description in Section 9.2.9 of the DCD. Revision 3. Figure 9.2.9-1, "Non-Essential Service Water System Flow Diagram," shows the system configuration. The system component parameters are provided in Table 9.2.9-1, "Non-ESW System Component Parameters."

The non-ESW is also described in Section 10.4.5 and shown on Figures 10.4.5-1.

ITAAC: The non-ESW does not require ITAAC, reference DCD Tier 1, Section 2.7.3.2.

TS: There are no TS for this area of review.

9.2.9.3 Regulatory Basis

The staff determined that no current NUREG-0800, SRP section was directly applicable to the non-ESW. While many specific requirements may not be applicable, in order to facilitate evaluation of DCD Tier 2 Section 9.2.9, the staff selected SRP Section 9.2.1 "Essential Service Water System," Revision 5, issued March 2007, SRP 9.2.2, "Component Cooling Water," Revision 3, issued March 2007; and SRP Section 10.4.3, "Turbine Gland Sealing System," Revision 3, issued March 2007 to be utilized as guidance.

The acceptance criteria contained in the noted SRPs which are of importance related to the non-ESW includes:

1. General Design Criteria (GDC) 2, “Design Basis for Protection Against Natural Phenomena,” as it relates to the capability of the design to maintain and perform its safety function following an earthquake or other natural phenomena. Acceptance for seismic criteria for the cooling water system is based on conformance with Position C.2 of RG 1.29, Seismic Design Classification,” for non-safety related portions of the non-EWS.

2. GDC 60,”Control of Releases of Radioactive Materials to the Environment,” as it relates to the control of releases of radioactive materials to the environment. As part of GDC 60 acceptance criteria, 10 CFR 20.1406, “Minimization of Contamination,” will also be considered.

Also, in accordance with 10 CFR 52.47(b)(1), the DC application must include the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the COL, the provisions of the Atomic Energy Act of 1954, and the NRC’s regulations.

9.2.9.4 Technical Evaluation

The staff’s evaluation of the non-ESW is based upon the information provided in Tier 1 Section 2.7.3.2, and Tier 2 Section 9.2.9, and in other DCD sections as referred to below. The non-ESW is shown in Tier 2, Figure 9.2.9-1 and Tier 2, Figure 10.4.5-1, “Circulating Water System Piping and Instrumentation Diagram.”

9.2.9.4.1 System Design Considerations

A. GDC 2, “Design Basis for Protection Against Natural Phenomena”

GDC 2 requires the SSCs, which are important to safety to be protected from natural phenomena such as seismic events. In accordance with Tier 2, DCD Table 3.2-2, “Classification of Mechanical and Fluid Systems, Components, and Equipment,” Item 51, the non-ESW has an equipment classification of 9, (nonsafety, and 10 CFR 50, Appendix B is not applied), is located in the TB, and has a seismic category of NS.

Based on the staff’s review of Tier 2, Table 3.2-4, “Seismic Classification of Buildings and Structures”, the TB is classified as Seismic Category II. In addition, the staff determined that there is no safety related SSCs in the TB based on the staff’s review of Tier 2, DCD Chapter 3.

The TB is subject to flooding. The bounding flooding source in the TB is the circulating water piping; however, the plant design includes a flooding relief system built into the TB wall. The design bases flooding event from the CWS has no safety related implication and is addressed in Section 10.4.5 of this SE.

In summary, the staff’s review finds that sufficient information was provided by the applicant to determine compliance of the applicable portions of the non-ESW system with the requirements of GDC 2, and that Position C.2 of RG 1.29 for non-safety related portions of the non-EWS has been satisfied. Failure of the non-ESW will not reduce the function of any SSCs important to safety or could result in injury to occupants of the control room since there is no safety-related equipment located in the TB.

B. GDC 60, "Control of Releases of Radioactive Materials to the Environment" and 10 CFR 20.1406.

The staff's review includes the non-ESW and CWS, which supplies cooling water to the non-ESW. As stated in Tier 2, DCD Section 9.2.9.2.2.5, "Valves," the water in this system does not normally contain radioactivity. This implies that neither the CWS or non-ESW could contain radioactivity and the staff finds that insufficient information was provided by the applicant to determine compliance of the applicable portions of the non-ESW system with the requirements of GDC 60. Therefore, the staff generated **RAI No. 203-1962, Question 9.2.1-1,** to address the issue related to control of releases of radioactive materials to the environment.

The applicant responded to **RAI 203-1962, Question 9.2.1-1,** in a letter dated March 25, 2009. The applicant stated that since the water in this system does not contain radioactivity, any special provisions against leakage to the atmosphere are not necessary. Therefore, since the non-ESW system has no radioactive contaminants, the requirements of 10 CFR 20.1406 are not applicable to this system.

The staff's review finds this RAI response acceptable since the non-ESW system is supplied by the CWS which does not contain radioactivity and the non-ESW system HX loads from TCS do not contain radioactivity for a condition in which the plate type HX develops leakage.

As described in the staff's review above, the applicant's response is adequate for Question 9.2.1-1 based on the review of DCD Tier 2 Section 9.2.9, Revision 2. The staff concludes that this item is therefore closed and the Non-ESW is in compliance with 10 CFR 20.1406 and GDC 60.

9.2.9.4.2 Technical Specifications

DCD Tier 2 Chapter 16, "Technical Specifications," are not applicable to the non-ESW because there are no TS associated with the non-ESW.

9.2.9.4.3 Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC)

There are no ITAAC associated with the Non-ESW. Based on a graded approach commensurate with the safety significance of the SSCs, the staff agrees that ITAAC are not required for the Non-ESW since the Non-ESW is a non-safety related system located in the TB, and no safety-related equipment is located in the TB.

9.2.9.4.4 Initial Test Program

Tier 2, Section 14.2.12.1.108, "Non-Essential Service Water (non-ESW) System Preoperational Test," describes the preoperational test to demonstrate the operation of the non-ESW prior to initial plant startup. Section 14.2 of this SE further addresses the staff's evaluation of the initial test program for US-APWR DCD.

9.2.9.5 Combined License Information

There are no COLs items identified in Tier 2, DCD. No COL items were identified by the staff that should be in Tier 2, DCD Table 1.8-2, “Compilation of All Combined Licenses Applicant Items for Chapter 1-19.”

9.2.9.6 Conclusion

The staff evaluated the non-ESW US-APWR standard plant design in accordance with the guidance that is referred to in the Regulatory Basis, Section 9.2.9.3 of this SE.

Based on the review summarized above, the staff concludes that the non-ESW design is consistent with the guidance of NUREG-0800, SRPs 9.2.1, 9.2.2 and 10.4.3 and that the information provided by the applicant adequately demonstrates that the requirements of 10 CFR Part 50, Appendix A, GDCs 2 and 60, and 10 CFR 20.1406 would be met. In addition, the staff concludes that ITAAC for Non-ESW are not required, which meets the provision of the Atomic Energy Act of 1954, and the NRC’s regulations which includes 10 CFR 52.47 (b)(1).

9.3 Process Auxiliaries

9.3.1 Compressed Air and Gas Systems

9.3.1.1 Introduction

The purpose of the compressed air and gas system (CAGS) is to supply compressed air and gas to various plant components. The only system safety function is to support containment isolation. The portions of the CAGS that serve that function are safety-related; other portions of the system are not safety-related.

9.3.1.2 Summary of Application

DCD Tier 1: The Tier 1 information associated with this section is found in DCD Tier 1, Section 2.7.2.

DCD Tier 2: The applicant has provided a Tier 2 description of the CAGS in Section 9.3.1 of the US-APWR DCD, summarized here in part, as follows:

> The CAGS is comprised of: (1) the instrument air system (IAS), (2) the station service air system (SSAS), and (3) the compressed gas system (CGS).
>
> The IAS provides compressed air to air-operated valves, HVAC air-operated dampers, and pneumatic instruments and controls. It consists of two 100 percent capacity trains. Each train consists of a compressor unit, an air receiver, and a dryer discharging to a common distribution header. Each compressor unit consists of an inlet air filter/silencer, a compressor, an intercooler, an aftercooler, a moisture separator, and associated controls. The compressors are cooled by water supplied from the component cooling water system. The IAS is shown in Figure 9.3.1-1. Major system components are described in Table 9.3.1-2.

The SSAS supplies compressed air for air-operated tools, air-operated pumps, and breathing air filtration units. Three 50 percent capacity trains are provided for the SSAS. Each train contains a compressor unit consisting of an inlet air filter/silencer, a compressor, an intercooler, an aftercooler, and a moisture separator. Cooling water to the service air compressors is supplied from the turbine plant closed cooling water system. The SSAS is shown in Figure 9.3.1-2. Major system components are described in Table 9.3.1-3.

The CGS provides various gases needed for purging, diluting, and inerting. It is comprised of the high pressure nitrogen gas subsystem, the low pressure nitrogen gas subsystem, the hydrogen gas subsystem, the carbon dioxide gas system, and the oxygen gas system. These subsystems provide distribution headers, piping, and valves used to transport gas supplied by the COL applicant.

ITAAC: The ITAAC associated with DCD Tier 2, Section 9.3.1 are given in DCD Tier 1, Section 2.7.2.2.

TS: The TS associated with DCD Tier 2, Section 9.3.1 are given in DCD Tier 2, Chapter 16, Section 3.6.3, “Containment Isolation Valves.”

9.3.1.3 Regulatory Basis

The relevant requirements of the Commission regulations for this area of review, and the associated acceptance criteria, are given in Section 9.3.1 of NUREG-0800 and are summarized below. Review interfaces with other SRP sections can be found in Section 9.3.1.I of NUREG-0800.

1. GDC 1 of Appendix A to 10 CFR Part 50, as it relates to safety-related SSCs designed, fabricated, and tested to quality standards commensurate with the importance of the safety functions to be performed.

2. GDC 2, as it relates to safety-related component cooling systems (CCSs) capability to withstand the effects of earthquakes.

3. GDC 5, as it relates to the sharing of safety-related SSCs.

4. 10 CFR 50.63, “Loss of all alternating power,” as it relates to the ability of the plant to withstand for a specified duration and recover from a SBO.

5. 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, the facility has been constructed and will operate in conformity with the COL, the provisions of the Atomic Energy Act of 1954, and the NRC’s regulations.

Acceptance criteria adequate to meet the above requirements are:

1. Acceptance for meeting the relevant aspects of GDC 1 is based on compliance with the criteria specified in American National Standards Institute/Instrument

Society of America (ANSI/ISA) S7.3-R1981 related to minimum instrument air quality standards.

2. Acceptance for meeting the relevant requirements of GDC 2, as it relates to seismic classification, is based on compliance to guidance provided in RG 1.29, Positions C.1 and C.2.

3. Acceptance for meeting the relevant requirements of GDC 5, as it relates to the sharing of safety-related SSCs, is based on the criteria set forth here for the system SSCs shared among multiple units.

4. Acceptance for meeting the relevant requirements of 10 CFR 50.63, as it relates to the system design and the ability of the plant to withstand for a specified duration and recover from an SBO, is based on RG 1.155.

9.3.1.4 Technical Evaluation

As described in US-APWR DCD, Revision 3, Tier 2 Section 9.3.1, “Compressed Air and Gas Systems,” the CAGS include the IAS, the SSAS, and the CGS.

Instrument air is provided by two oil-free, non-lubricated asymmetrical twin rotary screw air compressor packages that are connected to the IAS distribution system in parallel. During normal operation, one compressor operates to maintain system pressure and the other compressor is in standby. Each compressor package includes an intake filter, rotary screw compressor, silencer, intercooler, aftercooler, moisture separators, air receiver, air dryers, automatic load controls, relief valves and a discharge check valve. Duplex pre-filters are provided at the inlet of the instrument air dryer in order to protect the adsorption dryer units from oil aerosols and moisture droplets. Duplex after-filters prevent the carryover of desiccant dust from the dryer.

Service air is provided by three oil-free, non-lubricated asymmetrical twin rotary screw air compressor packages that are connected to the SSAS distribution system in parallel. During normal operation, one or two service air compressors are in operation with the remaining compressor(s) ready to be started manually if a compressor fails or demand exceeds the capacity of the operating units. Each service air compressor is equipped with an intake filter, rotary screw compressor, silencer, intercooler, aftercooler, moisture separators, automatic load controls, relief valves and a discharge check valve. Two parallel service air receivers and dryers are fed by any of the three compressors. Air leaving the dryers enters the SSAS air distribution system. The SSAS is capable of providing backup compressed air to the IAS by a cross connection at the distribution header, upstream of the dryers.

The gas sources, distribution headers, distribution piping, and the associated valves and instrumentation for the CGS are to be provided by the COL applicant and are not described in Revision 3 of the DCD.

The IAS and SSAS compressed air systems provide pressurized air for the following services throughout the plant:

- Instrument air for air-operated valves.
- Instrument air for HVAC dampers.
- Instrument air for pneumatic instruments and controls.

- Service air for air-operated tools.
- Service air for air operated pumps.
- Service air for breathing air filtration units.

The major components of the compressed air systems are located in the TB.

The staff reviewed the compressed air system (CAS) in accordance with NUREG-0800 "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," Section 9.3.1, "Compressed Air System," Revision 2, issued March 2007. The staff's acceptance of the CAS design is based on meeting the requirements of 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants," (GDC) 1, "Quality Standards and Records"; GDC 2, "Design Bases for Protection Against Natural Phenomena"; GDC 5, "Sharing of Structures, Systems, and Components (SSE)"; and 10 CFR 50.63, "Loss of All Alternating Current Power."

The staff identified a number of editorial errors within the application. These were identified in RAI 109-1637, Question 9.3.1-5. The applicant responded to RAI 109-1637, Question 9.3.1-5 in a letter dated December 25, 2008, and proposed to correct these errors in subsequent DCD revisions. After confirming that these corrections were completed, the staff finds that the problems identified in RAI 109-1637, Question 9.3.1-5 are resolved.

GDC 1

GDC 1 requires that safety-related SSCs be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions performed. The containment isolation valves (CIVs) and penetrations are the only safety-related components in the compressed air systems. The compressed air systems are not required to operate during or following an accident condition. The staff reviewed Figure 9.3.1-1, "Safety-Related Air-Operated Valves," and Figure 6.2.4-1, "Design Information Regarding Provisions for Isolating Containment Penetrations," (Sheet 35) for the IAS as well as Figure 9.3.1-2, "Nominal Component Design Data - Instrument Air System," and Figure 6.2.4-1 (sheet 38) for the SSAS as part of this SE. The portion of the IAS that penetrates containment at penetration P245 consists of a Class 1E powered motor operated isolation valve in the line outside of the containment structure, an in-line check valve located inside containment, and a locked closed manual valve inside containment that provides isolation to a system test connection flange that branches off of the main IAS line. In the event of an accident, the IAS motor-operated CIV isolates instrument air to components inside containment.

The design of the SSAS line penetrating the containment at penetration P230 includes a manual CIV that is locked closed during normal operation, and an in-line check valve inside the containment. A normally closed manual valve, also inside containment, provides isolation of a test connection point. In accordance with GDC 56, "Primary Containment Isolation," one automatic isolation valve inside containment and one locked closed CIV outside containment provides adequate containment isolation. DCD Tier 2, Chapter 16, "Technical Specification," 3.6.3, "Containment Isolation Valves," ensures the SSAS CIV is verified closed every 31 days in Modes 1, 2, 3, and 4.

SRP Section 9.3.1 specifies that in order to demonstrate conformance to GDC 1, the applicant needs to address Generic Issue 43, "Reliability of Air Systems," regarding the reliability of safety-related equipment actuated or controlled by compressed air. Additionally, NUREG-1275, "Operating Experience Feedback Report," and GL 88-14, "Instrument Air Supply System

Problems Affecting Safety-Related Equipment," also indicate compressed air contamination is a significant contributor to unreliability in safety-related air-actuated equipment. Finally, RG 1.68.3, "Preoperational Testing of Instrument and Control Air Systems," Position C.9 states that tests should be conducted to demonstrate that plant equipment designated by design to be supplied by the instrument and control air system is not being supplied by other compressed air supplies (such as service air) that may have less restrictive air quality requirements. An air system designed to air quality requirements of ANSI/ISA S7.3-R1981, "Quality Standard for Instrument Air," helps ensure that the CAS and connected components will perform their safety-function. The applicant stated in DCD Tier 2, Section 9.3.1.3, "Safety Evaluation," that the IAS meets the air quality standards for instrument air in accordance with ANSI/ISA-S7.3-R1981 and that periodic checks are performed to ensure IAS air quality.

In 2005, the staff assessed the effectiveness of Generic Issue 43, and GL 88-14. In conducting this assessment, the staff reviewed licensee event reports, inspection findings, and summary analyses of operating experience, such as initiating events studies and studies of the reliability of air systems and their components. In October, 2005, the staff published its findings in NUREG-1837, "Regulatory Effectiveness Assessment of Generic Issue 43 and Generic Letter 88-14."

On the basis of its assessment in NUREG-1837, the staff concluded that:

- Licensee and agency activities, such as the Maintenance Rule, GL 88-14, design-basis reconstitution, and others, have significantly improved air system and component performance and, thereby, resulted in improved reactor safety.

- Issuance of GL 88-14 and targeted NRC inspections led to the identification and resolution of air system design issues impacting safety-related systems and components, again resulting in improved reactor safety. As a result, based on data for pressurized-water reactors, major losses of instrument air are now infrequent, and prompt recovery from such losses is typical, which supports the staff's conclusion that reactor safety has improved.

- As evidenced by the ongoing discovery and correction of air system issues, licensee programs and NRC oversight activities provide assurance that the NRC and its licensees are effectively maintaining reactor safety in this area.

The staff's concerns cited in the above GL 88-14 are addressed by adopting ANSI/ISA-S7.3-R1981. For a plant that is not yet built or licensed, such as the US-APWR, SRP Section 9.3.1, Revision 2, which endorses the use of the ANSI/ISA standard, provides guidance for the design and testing of the IAS.

However, the DCD made no statement about the air quality of the SSAS when service air is used to provide backup compressed air to the instrument air system. In **RAI 109-1637. Question 9.3.1-1**, the staff requested the applicant to clarify in the DCD, the air quality specifications of the SSAS.

The applicant responded to RAI 109-1637, Question 9.3.1-1 in a letter dated December 25, 2008. In its response, the applicant stated that when the SSAS is cross-connected to provide instrument air, the air from the station service air system passes through the filter and dryer system of the IAS before entering the instrument air distribution header. The IAS filter/dryer unit ensures that the air from the SSAS, supplying the IAS loads, meets the air quality requirements specified in ANSI/ISA S7.3-R1981. The applicant also stated that on this basis no changes to the DCD were required.

The staff finds that the applicant's response adequately addressed the staff concerns identified in RAI 109-1637, Question 9.3.1-1. The design of the IAS meets the guidance of ANSI/ISA-S7.3-R1981 and Figure 9.3.1-1, "Instrument Air System," shows the cross-connection from the SSAS tying into the IAS upstream of the instrument air dryers and thus will ensure the SSAS air will meet the required air quality to the safety-related components normally supplied by the IAS. The staff concludes that the issue regarding the potential impact of air quality from the SSAS on safety-related air operated valves is resolved; therefore, RAI 109-1637, Question 9.3.1-1 is considered to be closed.

DCD Tier 2, Table 6.2.4-3, "List of Containment Penetrations and System Isolation Positions," (Sheet 6 of 8), part of the information provided for Penetration P245 indicated that the manual globe valve CAS-VLV-004 is normally open and is required to be open during shutdown. However, Figure 6.2.4-1, "Containment Isolation Configurations," (Sheet 35 of 50) indicated that CAS-VLV-004 is locked closed. In **RAI 109-1637, Question 9.3.1-2**, the staff requested the applicant to revise the DCD in order to identify the normal position of CAS-VLV-004.

The applicant responded to RAI 109-1637, Question 9.3.1-2 in a letter dated December 25, 2008. In its response, the applicant identified the discrepancy concerning the position of valve CAS-VLV-004 as an error in Table 6.2.4-3. The valve is to be normally closed and closed during shutdown and post-accident, not open. The applicant's response committed to correcting this error by revising the information in Table 6.2.4-3 , entitled "Description of Radiation Shielding for the Control Room in a LOCA," for the normal and shutdown positions of valve CAS-VLV-004 from open ("O") to closed ("C").

In Revision 2 of the DCD the applicant renamed all the CAS valves accordingly to their respective subsystem. The CAS-VLV-004 was renamed IAS-VLV-004. The staff verified that the proposed changes to DCD Tier 2 Table 6.2.4-3 were included as described in the RAI response, therefore, the concerns described in RAI 109-1637, Question 9.3.1-2 are considered to be closed.

DCD Tier 2, Section 14.2.12.1.91, "Instrument Air System Preoperational Test," describes the preoperational test of the IAS, which requires the system to:

- Demonstrate the system operates as designed,
- To assure the air quality meets requirements,
- To verify system response during normal and off-normal conditions, and
- To ensure that operations of large-capacity air components do not cause system transients.

DCD Tier 2, Section 14.2.12.1.92, "Station Service Air System Preoperational Test," describes the preoperational test of the SSAS, which requires the system to:

- Demonstrate the system operates as designed,
- To assure the air quality meets requirements,
- To verify system response during normal and off-normal conditions, and
- To ensure that operations of large-capacity air components do not cause system transients.

In DCD Tier 2, Section 14.2.12.1.117, “Compressed Gas System Preoperational Test,” describes the preoperational test of the CGS, which requires the system to:

- Demonstrate operation of the CGS (nitrogen gas subsystems and hydrogen gas subsystem only) to supply compressed gases to various loads that are important to safety, and

- Demonstrate that operations of large-capacity air components do not cause system transients.

The tests for the IAS and the SSAS were designed in accordance with RG 1.68.3 except for Regulatory Position C.7. Regulatory Position C.7 specifies testing of single failure criteria, but since these systems are not safety related or credited to mitigate any accident scenario; this criterion is not applicable. The staff finds that these tests are adequately design, and performing the test, as described in the corresponding subsections of DCD Tier 2, Section 14.2.12, would ensure that the systems meet all the assumptions used in the system design and analysis. Therefore, the staff found the proposed test to be acceptable.

Based on the information provided in the DCD and the staff evaluation discussed above, the staff concludes that the design of the CAGS satisfies GDC 1 regarding quality standards and records commensurate with the importance of the safety functions performed by the CAS.

GDC 2

In order for the CAGS to meet the requirements of GDC 2 as it relates to SSCs being capable of withstanding natural phenomena, RG 1.29, “Seismic Design Classification,” Positions C.1 and C.2 provide an acceptable method to meet this criterion.

The applicant stated that the only safety-related portions of the systems are the containment isolation valves and penetrations and that those components meet Seismic Category I requirements. The remaining components are classified as non-safety. In addition, DCD Tier 2, Section 9.3.1.3 states that the CAS (IAS and SSAS) are classified as moderate-energy systems and that there are no adverse environmental effects associated with a postulated failure of CAS piping. The applicant further states that a failure in the IAS or SSAS will not compromise the integrity of any safety-related component.

Additionally, none of the compressed air system components require Class 1E power supply except for the CIV in the IAS (IAS-MOV-002). All safety related air operated valve are designed to fail in the safe position upon losing compressed air.

Based upon the information provided by the applicant, the staff concludes the design of the safety-related portions of the compressed air system satisfies GDC 2 regarding protection from the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, and external missiles. Also, failure of the non-safety related portions of the CAGS satisfies GDC2 since its failures will not impact any safety-related SSC.

GDC 5

The applicant’s CAGS design must meet the applicable requirements of GDC 5, as to shared SSCs, which are important to safety, performing required safety functions. The US-APWR design is a single-unit design, and a COL applicant must comply with GDC 5 for a multiple-unit site; therefore, the staff finds that the CAGS design satisfies the requirements of GDC 5 as they relate to whether shared SSCs important to safety are capable of performing their required safety functions.

10 CFR 50.63

The IAS compressors and SSAS compressor are non-1E powered; and in the event of a LOOP, they do not receive power from the emergency GTGs. In the event of a SBO, the safety-related air-operated valves served by the CAS will fail in the safe position; thus, the compressed air system is not required to operate during a SBO. Therefore, the guidance of 10 CFR 50.63 regarding the capability for responding to a SBO is not applicable to the compressed air system.

ITAAC

DCD Tier 1, Section 2.7.2, “Compressed Air and Gas Systems,” does not have any specific ITAAC for the CAGS. DCD Tier 2 states that the only safety-related function served by the CAGS is in support of containment isolation, and this is discussed in DCD Tier 2 Section 6.2.4, “Containment Isolation System,” and DCD Tier 1 Section 2.11.2, “Containment Isolation System.” The staff’s evaluation of the containment isolation system is presented in Section 6.2.4 of this SE.

TS

There are no TS for this system specifically. However, LCO 3.6.3, “Containment Isolation Valves,” requires each containment isolation valve to be operable, which includes those that comprise the safety-related portions of the IAS and SSAS.

9.3.1.5 Combined License Information

DCD Tier 2, Revision 3 Section 9.3.6 contains one COL information item pertaining to the compressed air and gas system.

Item Number	Description	Section
COL 9.3(1)	The COL Applicant is to provide the high pressure nitrogen gas, low pressure nitrogen gas, the hydrogen gas, carbon dioxide, and oxygen supply systems.	9.3.1

The staff reviewed the proposed COL information item and found it to be inadequate. In RAI 109-1637, Question 9.3.1-4, the staff requested the applicant to provide a COL information item that clearly states that a COL applicant will be responsible for providing the tests and inspection requirements for the CGS.

The applicant responded to RAI 109-1637, Question 9.3.1-4, in a letter dated December 25, 2008. In its response, the applicant stated that the compressed gases of the CGS will be supplied to various systems, and that the only safety-related function for the compressed gases is containment isolation, and the containment isolation function of the gas supply lines is assigned to the systems being supplied by the CGS. The applicant clarified that DCD Tier 1, Section 2.11.2 verifies the containment isolation system. Furthermore, in a subsequent update to the DCD the applicant created DCD Tier 2, Section 14.2.12.1.117, which describes the preoperational testing criteria for the CGS.

The staff finds that the applicant's response adequately addressed the staff concerns identified in RAI 109-1637, Question 9.3.1-4. Assigning the responsibility for tests and inspection requirements for the safety-related containment isolation function to the separate systems being supplied by the CGS will adequately demonstrate that the compressed gas system will be capable of meeting its safety function. Completion of Preoperational Test 117 will demonstrate that the CGS has been constructed in a manner that will not adversely impact any safety-related components. Therefore, the staff concerns described in RAI 109-1637, Question 9.3.1-4, are considered to be addressed and the RAI is closed.

9.3.1.6 Conclusions

Based on the review of the DCD, and the clarification provided by the specified RAI responses, the staff concludes that the Compressed Air and Gas System meets the requirements of GDC 1, 2, 5 and 10 CFR 50.68 and the guidelines of SRP Section 9.3.1.

9.3.2 Process and Post-Accident Sampling Systems

9.3.2.1 Introduction

The process and post-accident sampling systems (PASS) contain equipment to collect representative samples of the various process fluids and provide the means to monitor the unit and various system conditions using the collected and analyzed samples. The process and PASS serves no safety function, except for providing containment isolation.

9.3.2.1 Summary of Application

DCD Tier 1: The Tier 1 information associated with this section is found in DCD Tier 1, Section 2.7.6.7.

DCD Tier 2: The applicant has provided a Tier 2 description of the process and PASS in Section 9.3.2 of the US-APWR DCD, summarized here, in part, as follows:

> The process and PASS includes the following sampling subsystems:
>
> - The primary liquid system (PLSS)
> - The primary gaseous sampling system (PGSS)
> - The PASS
> - The secondary sampling system (SSS)
> - The SG blowdown sampling system (SGBDSS)
> - Manual local grab sample provisions
>
> These systems include sample lines, pressure reduction valves, sample coolers, and automatic analysis equipment.
>
> The PLSS is designed to: (1) collect liquid samples from the RCS and auxiliary systems; (2) provide containment isolation; (3) analyze boron and radioactivity in liquid samples; and (4) provide protection against exposure and contamination during collection of samples, and route spilled water and wash water to the liquid waste management system (LWMS). Sampling points for each sampling activity are specified in Table 9.3.2-1.

The PGSS is designed to: (1) provide gaseous samples of containment atmosphere; (2) provide containment isolation; (3) collect gaseous samples from auxiliary systems; and (4) provide protection against exposure and contamination during collection of samples, and send a residual dew condensation to the LWMS. Sampling points for each sampling activity are specified in Table 9.3.2-1.

The PASS has specific post-accident sampling lines, which have the capability to obtain and analyze highly radioactive samples of the reactor coolant, refueling water storage pit water, and containment atmosphere. The PASS is designed to obtain post-accident liquid samples as listed in Table 9.3.2-2.

The SSS is designed to continuously monitor water samples from the turbine cycle as listed in Table 9.3.2-4.

The SGBDSS is designed to: (1) monitor secondary water quality in the SGs to maintain acceptable secondary coolant water chemistry; (2) detect primary to secondary tube leakage; and (3) provide containment isolation. The sample points are discussed in Table 9.3.2-5.

Local grab sampling points are provided as needed for various processes. Grab sample point for liquids are identified in Table 9.3.2-6.

In summary, DCD Section 9.3.2 states that neither the process sampling system, which includes the PLSS and the PGSS, nor the PASS has a safety design basis (apart from containment isolation). All sample lines use 3/8-inch stainless steel tubing. It is necessary for liquid samples from the RCS to be both cooled and depressurized before actual measurements occur. The PLSS is actually a part of the PASS and serves to collect RCS samples during and after accidents. In addition, the applicant describes the SSS and the SGBDSS, which monitors the secondary system water. Detailed descriptions of all the sample points and the type of sampling done at each are contained in DCD Tables 9.3.2-1, 9.3.2-2, 9.3.2-3, 9.3.2-4, 9.3.2-5, and 9.3.2-6. These descriptions include PLSS samples of the RCS, gaseous samples from containment, sampling of containment sumps and tanks, and sampling of secondary side water.

ITAAC: The ITAAC associated with DCD Tier 2, Section 9.3.2 are given in DCD Tier 1, Section 2.7.6.7.2.

TS: The TS associated with DCD Tier 2, Section 9.3.2 are given in DCD Tier 2, Chapter 16, Section 3.6.3, Containment Isolation Valves. TS 3.7.14 deals with secondary specific activity, and TS 3.4.16 deals with the reactor coolant specific activity. In addition, Section 5 (Program and Manuals) of DCD Tier 2, Chapter 16, includes three programs that relate to the process and PASS: Section 5.5.3 deals with post-accident sampling, Section 5.5.9 includes the SG Program, which requires sampling, and Section 5.5.10 regarding the Secondary Water Chemistry Program deals with sampling of secondary water.

9.3.2.3 Regulatory Basis

The relevant requirements of the Commission regulations for this area of review, and the associated acceptance criteria, are given in Section 9.3.2 of NUREG-0800 and are summarized below. Review interfaces with other SRP sections can be found in Section 9.3.2.I of NUREG-0800.

1. 10 CFR 20.1101(b), as it relates to providing engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public ALARA.

2. GDC 1, "Quality Standards and Records," of Appendix A to 10 CFR Part 50, as it relates to the design of the process and PASS and components in accordance with standards commensurate with the importance of their safety functions.

3. GDC 2, "Design Bases for Protection Against Natural Phenomena," as it relates to the ability of the process and PASS to withstand the effects of natural phenomena.

4. GDC 13, "Instrumental and Control," as it relates to monitoring variables that can affect the fission process, the integrity of the reactor core, and the RCPB.

5. GDC 14, "Reactor Coolant Pressure Boundary," as it relates to assuring the integrity of the RCPB by sampling for chemical species that can affect the RCPB.

6. GDC 26, "Reactivity Control System Redundancy and Capability," as it relates to reliably controlling the rate of reactivity changes by sampling boron concentration.

7. GDC 41,, "Containment Atmosphere Clean-Up," as it relates to reducing the concentration and quality of fission products released to the environment following postulated accidents by sampling the chemical additive tank for chemical additive concentrations to ensure an adequate supply of chemicals for meeting the material compatibility requirements and the elemental iodine removal requirements of the containment spray and circulation solutions following a postulated accident.

8. GDC 60, "Control of Releases of Radioactive Materials to the Environment," as it relates to the capability of the process and PASS to control the release of radioactive materials to the environment.

9. GDC 63, "Monitoring Fuel and Waste Storage," as it relates to detecting conditions that may result in excessive radiation levels in the fuel storage and radioactive waste systems.

10. GDC 64, "Monitoring Radioactivity Releases," as it relates to monitoring the containment atmosphere and plant environs for radioactivity.

11. 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.

Acceptance criteria adequate to meet the above requirements are:

1. The applicant's design is such that the process and PASS has the capability to sample all normal process systems and principal components, including provisions for obtaining samples from at least the following points:

    - Reactor coolant (e.g., letdown system).
    - Refueling (borated) water storage tank.
    - ECCS core flooding tank.
    - BA mix tank.
    - Boron injection tank.
    - Chemical additive tank.
    - SFP.
    - Secondary coolant (e.g., condensate hotwell).
    - Pressurizer tank.
    - SG blowdown (if applicable).
    - Secondary coolant condensate treatment waste.
    - Sumps inside containment.
    - Containment atmosphere.
    - Gaseous radwaste storage tanks.

2. The guidelines of RG 1.21, Position C.2.

3. The EPRI PWR Water Chemistry Guidelines are used to meet the requirements of the relevant GDC.

4. The plant TS include the required analysis and frequencies.

5. The following guidelines should be used to determine the acceptability of the process and PASS functional design:

    - Provisions should be made to ensure representative samples from liquid process streams and tanks. For tanks, provisions should be made to sample the bulk volume of the tank and to avoid sampling from low points or from potential sediment traps. For process stream samples, sample points should be located in turbulent flow zones. The guidelines of Regulatory Position C.6 in RG 1.21 are followed to meet these criteria.

    - Provisions should be made to ensure representative samples from gaseous process streams and tanks in accordance ANSI/Health Physics Society (HPS) Standard N13.1-1999. The guidelines of Regulatory Position C.6 in RG 1.21 are followed to meet this criterion.

    - Provisions should be made for purging sampling lines and for reducing plate out in sample lines (e.g., heat tracing). The guidelines of Regulatory Position C.7 in RG 1.21 are followed to meet this criterion.

    - Provisions should be made to purge and drain sample streams back to the system of origin or to an appropriate waste treatment system in accordance with the requirements of 10 CFR 20.1101(b) to keep radiation exposures at ALARA levels. The guidelines of Regulatory Positions 2.d(2), 2.f(3), and 2.f(8) in RG 8.8 are followed to meet this criterion.

- Isolation valves should fail in the closed position, in accordance with the requirements of GDC 60 to control the release of radioactive materials to the environment.

- Passive flow restrictions to limit reactor coolant loss from a rupture of the sample line should be provided in accordance with the requirements of 10 CFR 20.1101(b) to keep radiation exposures to ALARA levels and the requirements of GDC 60 to control the release of radioactive materials to the environment. The guidelines of Regulatory Position 2.i.(6) in RG 8.8 should be followed to meet this criterion. Redundant environmentally qualified, remotely operated isolation valves may replace passive flow restrictions in the sample lines to limit potential leakage. The automatic containment isolation valves should close on containment isolation signals or safety injection signals.

6. To meet the requirements of GDC 1 and GDC 2, the applicant's seismic design and quality group classification of sampling lines, components, and instruments for the process and PASS should conform to the classification of the system to which each sampling line and component is connected (e.g., a sampling line connected to a Quality Group A and Seismic Category I system should be designed to Quality Group A and Seismic Category I classification), in accordance with Regulatory Positions C.1, C.2, and C.3 in RG 1.26; Regulatory Positions C.1, C.2, C.3, and C.4 in RG 1.29, and the guidelines of RG 1.97. Components and piping downstream of the second isolation valve may be designed to Quality Group D and non-seismic Category I requirements, in accordance with Regulatory Position C.3 in RG 1.26.

7. Three Mile Island (TMI) Action Plan Item III.D.1.1 in NUREG 0737, as it relates to the provisions for a leakage control program to minimize the leakage from those portions of the process and PASS outside of the containment that contain or may contain radioactive material following an accident. 10 CFR 50.34(f)(2)(xxvi) provides equivalent requirements for those applicants subject to 10 CFR 50.34(f).

9.3.2.4 Technical Evaluation

This Section discusses two main issues—location of sample points in Section 9.3.2.3.1 and sampling procedures in Section 9.3.2.3.2.

9.3.2.4.1 Sampling Locations

SRP 9.3.2 recommends a number of sample locations to be included in order to satisfy regulatory criteria; these are listed in SRP 9.3.2. The contents of this table are duplicated in columns 1-2 of the table below. The applicant has listed numerous sample locations in tables of DCD 9.3.2, and these are used to fill out the last two columns of the table below.

Sample Location for PWR	GDC	DCD	Sample Point

		Table	**No.**
Reactor coolant (e.g., letdown system)	13, 14, 26, 64, 60	9.3.2-1	1-8
Refueling (borated) water storage tank	13, 26	9.3.2-6	8
ECCS core flooding tank	13	9.3.2-6	4-7
Boric acid mix tank	13, 26	9.3.2-6	1,3
Boron injection tank	13	9.3.2-6	1,2
Chemical additive tank	13, 14, 41		
Spent fuel pool	63, 60	9.3.2-6	29, 30
Secondary coolant (e.g., condensate hotwell)	13, 14	9.3.2-4	1-30
Pressurizer tank	64, 60	9.3.2-1	2, 3
Steam generator blowdown (if applicable)	14, 64, 60	9.3.2-5	1-4
Secondary coolant condensate treatment waste	64, 60	9.3.2-4	8
Sumps inside containment	64, 60	9.3.2-6	8-16
Containment atmosphere	64, 60	9.3.2-1	16
Gaseous radwaste storage tanks	63, 64, 60	9.3.2-1	11

The tables in the DCD also summarize the species that are to be measured at each sample point. However, the sample points for the RCS do not mention any sampling for sulfate or lithium, which are specified as control parameters by the EPRI Guidelines. In its response to RAI 294-2129, Question 09.03.02-01 (Reference 4), dated May 14, 2009, the applicant agreed to include analysis for Li and SO_4 in the RCS Hot Leg sample, and modified DCD Table 9.3.2-1 to include these species. These changes are incorporated in Revision 2 of the DCD in Section 9.3.2 and Table 9.3.2-1.

As indicated by the blank spaces in the table above, there is no mention in the DCD concerning sampling of chemical additive tanks, which is recommended in SRP 9.3.2 in order to satisfy GDC 13, 14, and 41. The staff notes that the intention of this recommendation is monitoring of tanks containing containment spray additives for fission product control. In its response to RAI 294-2129, Question 09.03.02-02 (Reference 4), dated May 14, 2009, the applicant stated that chemical tanks containing ammonia, morpholine, dimethylamine, and hydrazine have known inventories based on the mixing of commercial chemicals with purified makeup water. The staff recognizes this is sufficient and that no sampling of these tanks is necessary because the mixing procedures provided by the vendors provide sufficient controls.

Among the sample points for the PLSS (DCD Table 9.3.2-1) is the “Pressurizer Vapor Space” (Sample Point 2), which is to be sampled for dissolved oxygen. The staff requested clarification of this liquid sampling of vapor space. In its response to RAI 294-2129, Question 09.03.02-03 (Reference 4), dated May 14, 2009, the applicant confirmed that this is not a liquid sample, but a gas-phase sample taken under unusual circumstances to corroborate or understand liquid sampling of the pressurizer.

The tables in the DCD list many more locations in addition to those recommended in SRP 9.3.2; however, none of the sample points listed in the DCD 9.3.2 tables mentions sampling for suspended solids (except for feedwater). This is important because samples should be representative, and also because solids can accumulate in or plug sample lines. In its response to RAI 294-2129, Question 09.03.02-04 (Reference 4), the applicant agreed to include analysis for suspended solids in the RCS Hot Leg sample and containment gas sample, and modified

DCD Tables 9.3.2-1 and 9.3.2-2 to include these species in Revision 2 of the DCD. In the case of the containment gas sample, applicant notes that the primary significance is for post-accident sampling, because only a negligible amount of particulate is expected in the containment gas space during normal operation.

Also in its response to RAI 294-2129, Question 09.03.02-04 and Question 09.03.02-6 (Reference 4), dated May 14, 2009, the applicant noted that both liquid and gas sampling will provide representative samples and are unlikely to plug sample lines. In particular, the PLSS will involve sample line sizes and flow rates to create turbulent flow within them, thus ensuring that solids remain suspended. The staff finds that such a plan will satisfy the guidelines of RG 1.21 for both uniformity and timeliness (Sections 6 and 8, respectively). For liquid samples from tanks, the tanks will be thoroughly mixed before sampling and sample ports will be located near the discharge points. The applicant modified Revision 2 DCD (Section 9.3.2.2.6) to better describe these plans. The PGSS (and PASS) follows the guidance in ANSI/HPS N13.1-1999, as recommended in SRP 9.3.2. The design features will include smooth inner surfaces, non-corrosive materials, and pipe routing so as to minimize plate out or sedimentation. In addition, purge gas is effective in minimizing line blockage. In its response to RAI 294-2129 Question 09.03.02-06 (Reference 4), dated May 14, 2009, the applicant stated that the inlet port for PASS (and PGSS) is near the top of containment, but, removed from containment fans, in a position to give representative samples of airborne components. DCD Section 9.3.2.2.2 was revised in Revision 2 to incorporate this information. The staff finds that these features of the PASS design and operation meet the guidance in SRP 9.3.2 and are, thus, acceptable.

9.3.2.4.2 Sampling Procedures

The DCD states that the SSS and SGBDSS draw continuous samples through analyzers, which are checked periodically by comparison with grab samples. All other samples (including all from the RCS) are collected manually (i.e., “grab samples”). Grab sample instruments are calibrated regularly with known standards. Liquid samples from the RCS are conducted through stainless steel pipe to a common sample room outside of containment. The sample lines from the RCS hot leg include extra length to delay arrival of the sample sufficiently to allow decay of ^{16}N. Shielded compartments are available in the sample room to minimize exposure to personnel from potentially radioactive samples. The sample panel is situated in a ventilated, hooded enclosure to further reduce the possibilities of exposure or contamination. Spilled or leaked water is routed to a waste holdup tank for processing. The DCD does not supply information regarding the actual handling of samples, especially those that might contain radioactive materials. The local grab sample ports use quick-disconnect couplings, but there is no information in the DCD on the time it takes for samples to be analyzed once they are drawn. In its response to RAI 294-2129, Question 09.03.02-05 (Reference 4), the applicant has provided estimates of sampling times, which include all preparation and analysis steps. For routine sampling of the RCS (grab samples), the estimate is about five hours. These samples would identify concentrations of impurities which could require immediate attention (i.e. within 24 hours), and is, thus, acceptable. For gas and liquid sampling under accident conditions, sampling time is about two hours, which is adequate to meet the eight hour time limit for boron measurement (Reference 1). It is also well within the 24 hour limit for containment airborne radioactivity and dissolved gasses in the RCS. Thus, the staff concludes that the applicant is able to meet the sampling time requirements stipulated in Reference 1.

Gaseous samples are drawn from several containment locations, as described in DCD Table 9.3.2-1, and, thus, meet the requirements of GDC 64. As in the case of most liquid samples, these are “grab samples,” and the sample lines must be purged before the actual sample is isolated. Heat tracing and insulation are used on high-temperature lines to limit plate-out. These procedures help to ensure representative samples, as recommended in RG 1.21 (C.6). The DCD states that dew condensation liquid collected in gas sample containers is routed to holdup tanks, as required by GDC 60. However, no mention is made about measuring this condensed liquid for fission products or other contaminants. In its response to RAI 294-2129, Question 09.03.02-07 (Reference 4), the applicant stated that dew condensation would not be significant. Later, in its response to RAI 448-3469, Question 09.03.02-11 (Reference 5), dated September 28, 2009, the applicant recognized the possibility of dew condensation, especially during accident conditions. The applicant then describe a change to sampling procedures which will allow measurement of gas samples at elevated temperatures to prevent condensation. This change involves revision of DCD Section 9.3.2.2.2, which the staff confirmed in Revision 3 of the US-APWR DCD. The staff finds the combination of heat tracing of sample lines, return of samples to the containment, and procedures to minimize radiation exposure to technicians, provision of representative samples, even during accidents or in other situations where condensable gases are part of the sample stream, is acceptable.

The PASS draws liquid samples from the RCS hot leg and the RWST, and gas samples from the containment atmosphere. The liquid lines lead to a dedicated sample vessel with lead shielding and a shielded sample hood. The hood has an extended handle to manually collect samples and protect personnel from radiation exposure, in accordance with requirements of Reference 1 (Position 6). The applicant states that the liquid sampling system has the capability to take a boron measurement in 8 hours and measurements of dissolved gasses, pH, and chloride within 24 hours after an accident, as required by Reference 1.

As mentioned above, the SSS draws continuous samples through online analyzers, which measure for pH, conductivity, dissolved oxygen, oxygen scavenger, Si, Cl, Na, and SO_4. Continuous analyzers are also used by the SGBDSS. The continuous measurements in both systems are calibrated/validated by periodic comparison with grab samples. Both of these systems are concerned with the purity of secondary water, to ensure materials integrity in the RCPB, as required by GDC 13 and GDC 14, and are, thus, acceptable.

9.3.2.4.3 NUREG-0737 Three Mile Island (TMI) Action Item III.D.1.1

TMI Action Plan Item III.D.1.1 in NUREG-0737 and 10 CFR 50.34(f)(2)(xxvi) require a leakage control program to minimize the leakage from those portions of the PSS outside of the containment that contain or may contain radioactive material following an accident. Containment and primary coolant sampling is a system listed by Item III.D1.1 (among others) as potentially in scope of the requirement. DCD Table 6.3-1, Sheet 2, describes design features facilitating compliance with NUREG-0737 Item III.D.1.1 for the ECCS systems. However, no similar design details were provided for other systems that may be in scope of the requirement, including process sampling. Although DCD Section 9.3.2 listed NUREG-0737 Item III.D.1.1 and 10 CFR 50.34(f)(2)(xxvi) among the design bases for the process and postaccident sampling systems, no further detail was provided in DCD Section 9.3.2 on how leakage control is ensured. Additionally, DCD Chapter 16, TS 5.5.2, “Primary Coolant Sources Outside Containment,” states the following:

> This program provides controls to minimize leakage from those portions of systems outside containment that could contain highly radioactive fluids during a serious transient or accident to levels as low as practicable. The systems include

> Containment Spray, Safety Injection, Chemical and Volume Control, and Sampling System. The program shall include the following:
>
> a. Preventive maintenance and periodic visual inspection requirements and
> b. Integrated leak test requirements for each system at least once per 24 months.

The applicant described a program intended to fulfill the requirements of NUREG-0737 Item III.D.1.1. However, TS 5.5.2 did not contain all the elements required by NUREG-0737 Item III.D.1.1. Furthermore, the initial and periodic tests required by Item III.D.1.1 would be performed by the COL holder. However, the US-APWR DCD did not identify a COL information item to ensure the COL holder has a leakage control program, and the initial leak test was not addressed in the initial test program information included in the DCD. Therefore, the staff requested the following additional information with RAI 346-2641, Question 09.03.02-10:

1. List the systems considered to be in scope of the requirements of NUREG-0737 Item III.D.1.1 or 10 CFR 50.34(f)(2)(xxvi). If any systems expected to contain radioactive materials after an accident are excluded from the leakage detection program, justify the exclusion of these systems.

2. Describe the design provisions that facilitate minimization and detection of leakage for each of the systems considered to be in scope of item III.D.1.1 or 10 CFR 50.34(f)(2)(xxvi), if not already described in the DCD.

3. Discuss the need to include a COL information item in the DCD to ensure the COL holder develops a program for leakage monitoring and prevention to fulfill the requirements of NUREG-0737 Item III.D.1.1 and 10 CFR 50.34(f)(2)(xxvi).

4. Clarify whether proposed TS 5.5.2 intended to fulfill the requirements of Item III.D.1.1 in NUREG-0737 and 10 CFR 50.34(f)(2)(xxvi). If so, these criteria should be referenced in the TS.

5. In DCD Tier 1 and Tier 2, provide the initial test program information for leakage control and detection for all systems outside containment that contain (or might contain) accident source term radioactive materials following an accident.

In its response to RAI 346-2641, Question 09.03.02-10, Item 1, dated June 8, 2009, the applicant listed the PASS, Residual Heat Removal System (RHRS), Containment Spray System (CSS), and High Head Injection System (HHIS) as the systems in scope of the NUREG-0737 Item III.D.1.1 requirements.

In its response to RAI 346-2641, Question 09.03.02-10, Item 2 for the PSS dated June 8, 2009, the applicant described the design features facilitating compliance as follows:

> The PASS is described in Section 9.3.2.2.3. The samples taken are grab samples, and sampling is only performed when necessary. When post-accident sampling is not required, containment isolation integrity is maintained by inner and outer containment isolation valves. Any venting through the PASS is released through the HVAC system, and then re-routed to a line with High Efficiency Particulate Air (HEPA) and charcoal filters when high radiation is detected.

The response to RAI 346-2641, Question 09.03.02-10, Item 2 also stated, in part, that the leakage detection system is included in the Equipment and Floor Drainage Systems described in Chapter 9, Section 9.3.3. However, it was not clear from the information in Section 9.3.3 how sensitive the leak detection systems were, or whether the systems provided the capability to determine the leakage rate. For a leakage detection system to facilitate minimization of the leakage rate, the detection system must be capable of detecting relatively small leaks and allow measurement of the leakage rate, so that prompt corrective maintenance can be performed as needed. Therefore, the staff issued follow up RAI 461-3686, Question 09.03.02-12, Item 3, requesting that the applicant provide the sensitivity of the leakage detection system described in DCD Section 9.3.3 in terms of leakage rate, and whether the system is capable of determining leakage rate or, if not, to justify how the system design supports the goal of "continuing leak reduction" of NUREG-0737 Item III.D.1.1, Position 2.

In its response to Item 3 of RAI 461-3686, Question 09.03.02-12, dated November 11, 2009, the applicant indicated that "a few gallons" of Engineered Safety Features (ESF) leakage can be detected by the leakage detection system, and that the leakage rate can be calculated based on the level change time intervals. The applicant also indicated an alarm sounds in the MCR allowing an operator to be dispatched to investigate the leak and take action as necessary, including opening a valve to drain the liquid to the sump. However, the applicant did not provide a quantitative leakage detection sensitivity in gallons per minute (gpm) or gallons per hour (gph). It was unclear to the staff why the applicant did not find it necessary to identify the actual leak rate sensitivity. It was also not clear whether the ESF leak rates could be characterized after an accident if there are highly radioactive fluids in the system, since operator action is required to open a valve to drain the liquid to the sump. Therefore, in RAI 526-4121, Question 09.03.02-14, the staff requested the applicant to provide the actual leakage rates in gpm or gph or justify why this is not necessary, and to clarify whether the leakage rate can be characterized in a post-accident situation. In its response to RAI 526-4121, Question 09.03.02-14, dated April 7, 2010, the applicant stated that characterization of the liquid can be estimated based on the data available and it can be confirmed by sampling and analysis. The applicant also explained that the sensitivity of the leakage rate can be correlated to the liquid volume between the setpoints of the level switches and the accumulation time of the sump. The staff finds this response acceptable because it informs the operator if there is a leakage in the system and the rate of the leakage.

The response to RAI 346-2641, Question 09.03.02-10, Item 2 as supplemented by the response to RAI 461-3686, Question 09.03.02-12, Item 3 described the leak detection system for the ESF systems (including RHRS, HHIS, and CSS). However, it was not clear if there was a similar leak detection system for the PSS, CVCS, or Gaseous Waste Management System (GWMS). Therefore, in RAI 526-4121, Question 09-03-02-16, the staff requested the applicant to explain whether a similar system for online leak detection exists for the PSS, CVCS, and GWMS. In its response to this RAI dated April 7, 2010, the applicant explained that the portions of the PSS that may contain primary coolant are provided with leak detection systems. The applicant also described the leak detection system for the CVCS in its response to RAI 526-4121, Question 09.03-02-15. As for the GWMS, the applicant explained that the Gaseous Waste Management (GWM) instrumentation and controls are capable of identifying leaks.

Additionally, in its response to RAI 346-2641, Question 09.03.02-10, Item 3, the applicant stated that a COL information item to ensure that the COL holder develops a program for leakage monitoring and prevention to fulfill the requirements of Item III.D.1.1 is not considered necessary because the systems have necessary features built into the design as listed above. The applicant further stated that additional information on the leakage monitoring and prevention program is covered in Chapter 16, TS 5.5.2, and that the COL holder will need to comply with these TS and therefore will develop the leakage monitoring and prevention program as described in 5.5.2. Additionally, in response to Item 4 of the RAI, the applicant indicated the absence of regulatory criteria referenced in the TS is due to the fact that the US-APWR TS are based on NUREG-1431, “Standard Technical Specifications,” Number 5.5.2, which does not include the regulatory criteria. Because the list of systems in TS 5.5.2 did not match the systems in scope for the US-APWR, and TS 5.5.2 does not reference the specific regulatory criteria, in RAI 461-3686, Question 09.03.02-12, Item 5, the staff requested the applicant to describe how the appropriate requirements will be communicated to COL holders to ensure they implement a leakage monitoring and reduction program including the systems identified as in-scope in Reference 1, and meeting the requirements of NUREG-0737 Item III.D.1.1.

In its response to RAI 461-3686, Question 09.03.02-12 ,Item 5, dated November 17, 2009, the applicant stated that TS 5.5.2 would be revised to reflect the systems within the scope of NUREG-0737 Item III.D.1.1 as described in the response to Item 4. The applicant also stated in response to Item 5 that a COL information item is necessary to ensure that the COL applicant develops the programs addressed in COL Information Item 13.4(1). The applicant further stated that it is not necessary to include an additional COL information item. However, the staff did not agree with the statement in the response to Item 5 that COL Information Item 13.4(1) will ensure the COL will develop the leakage monitoring and prevention program, because COL Information Item 13.4(1) only applies to those operational programs listed in SECY-05-0197. The NUREG-0737 Item III.D.1.1 Leakage Monitoring and Prevention Programs is not one of the programs considered by SECY-05-0197 to be an operational program. Therefore, in RAI 526-4121, Question 09-03-02-13, the staff requested that the applicant explain how the regulatory basis (i.e., NUREG-0737 Item III.D.1.1 or 10 CFR 50.34 (f)(2)(xxvi)) for the program identified in TS 5.5.2 will be communicated to the COL applicant, to ensure the COL develops a program with appropriate methods and acceptance criteria. In its response to this question dated April 7, 2010, the applicant stated it will revise the DCD to include COL Information Item 13.4(2) to ensure the COL holder implements a program meeting the requirements of NUREG-0737 Item III.D.1.1 for the systems identified in TS 5.5.2. The staff confirmed this modification of the DCD in Revision 3 of the US-APWR DCD.

The response to RAI 461-3686, Question 09.03.02-12 Item 4 clarified that it was not the intent of the response to RAI 346-2641, Question 09.03.02-10 to exclude the CVCS and GWMS from the scope of the leakage monitoring and control program, even though these systems are not expected to contain radioactive materials after a LOCA, and indicated that TS 5.5.2 would be revised to add the CVCS and GWMS to the list of in-scope systems. In its response to RAI 461-3686, Question 09.03.02-12 Item 4, the applicant also clarified that the CVCS is included within the scope of the leakage monitoring and prevention program. The staff finds this response acceptable because the addition of the CVCS and GWMS to the in-scope systems listed in TS 5.5.2 makes the list of in-scope systems consistent with the recommended in-scope systems from NUREG-0737 Item III.D.1.1. However, the “leakage detection design” for the CVCS mentioned in the response to RAI 346-2641, Question 09.03.02-10 Item 2 was not described in DCD Section 9.3.4. In addition, DCD Tier 2 Section 9.3.4.3 states “The CVCS does not provide an ECCS function. Therefore, the provision for a leakage detection and control program in accordance with 10 CFR 50.34 (f) (xxvi) does not apply.” Therefore, in RAI 526-4121, Question 09.03.02, the staff requested the applicant to remove the statement from the DCD that the CVCS is not in scope of 10 CFR 50.34 (f) (xxvi). In its response to this question dated April 7, 2010, the applicant will delete the statement from the DCD. The staff confirmed this modification of the DCD in Revision 3 of the US-APWR DCD.

In its response to Item 5 of RAI 346-2641, Question 09.03.02-10, dated June 8, 2009, the applicant stated that the initial test program information for leakage detection in the ESF rooms is cited in Section 14.2.12.1.77. Containment isolation valves and HVAC systems are also tested in accordance with their initial test programs cited in Section 14.2.12. The staff reviewed the initial test program information and found that the information did not include a method for measuring initial system leakage rate or quantitative acceptance criteria for initial system leakage rates. Therefore, in RAI 461-3686, Question 09.03.02-12 Items 1 and 2, the staff requested the applicant provide this information.

In its response to RAI 461-3686, Question No. 09.03.02-12 Item 1, dated November 17, 2009, the applicant clarified that Preoperational Test 14.2.12.1.77 does not determine the initial system leak rate, but verifies the calibration and functionality of the miscellaneous leakage detection system installed in each ESF equipment room, which are then used to determine and monitor the leak rate. The applicant further stated in response to Item 1 that the initial system leak rate within the Engineered Safeguards (ES) equipment rooms is measured during initial performance of the program identified in TS Section 5.5.2, Primary Coolant Sources Outside Containment, which is performed during Hot Functional Testing. The applicant also added the initial determination of the leak rate to the RCS Hot Functional Preoperational Test in DCD Tier 2 Section 14.2.12.1.1 in a markup transmitted by letter dated October 28, 2009 (Reference 6). The markup added Item C.7 to test methods stating, “The leakage control program plant procedures which implement Technical Specifications program 5.5.2, Primary Coolant Sources outside Containment, are performed while the plant is in hot standby.” The staff finds the applicant’s response acceptable because the initial leak rate will be determined prior to initial criticality.

In its response to RAI 461-3686, Question 09.03.02-12 Item 2, dated November 17, 2009, the applicant stated that the program for leakage monitoring and prevention identified in TS Section 5.5.2 including the acceptance criteria for allowable leakage rates will be developed by the COL applicant. The applicant also indicated that the total ESF system leakage of 17.6 lb/hr from DCD Table 15.4.8-3 is a conservative value based on a doubling of the assumed leakage rates from all ESF sources that may contain highly radioactive recirculation water, such as valve packing glands, pump shaft seals, flanged connections), and that the total ESF system leakage in general is well below this rate. On this basis, the staff finds that the ESF leakage criterion of 17.6 lb/hr is acceptable for use by the COL applicants as a basis for developing programmatic acceptance criteria for ESF systems leakage rate.

Based on the above discussion, the staff finds the applicant has appropriately described the recommended program to meet the requirements of NUREG-0737 Item III.D.1.1, because it has included the appropriate systems in scope, provided equipment capable of detecting and quantifying leaks, provided an acceptable basis for program acceptance criteria, and provided an appropriate initial test for system leakage.

Compliance with NUREG-0737 Item III.D.1.1 and 10 CFR 50.34 (f)(2)(xxvi) is applicable to several other systems for the US-APWR. The staff’s evaluation of the compliance with NUREG-0737 Item III.D.1.1 for the RHRS/Containment Spray Recirculation, ECCS (including High-Head Injection System), CVCS, and GWMS, is discussed in Sections 5.4.7, 6.3, 9.3.4, and 11.3 of this SE.

9.3.2.5 Combined License Information

There are none identified in the US-APWR DCD for Section 9.3.2.

9.3.2.6 Conclusions

The applicant has described extensive sampling of liquid and gaseous systems, including concentrations of impurities and added chemicals in RCS and secondary water, and fission products in water and gas space. The sampling locations and procedures satisfy SRP 9.3.2, RG 1.21, and EPRI guidelines, and, hence, they meet the requirements of GDC 13, 14, 26, 41, 60, 63, 64, and 10 CFR 20.1101(b). The staff concludes that the criteria of NUREG-0737 (as amended by SECY-93-087) are met for the PSS. Thus, the staff concludes, based on information supplied by the applicant that the applicable regulatory criteria have been satisfied.

9.3.2.7 References

1. *Clarification of TMI Action Plan Requirements*, NUREG-0737, U.S. Nuclear Regulatory Commission (November 1980). Modified by Policy Issue SECY-93-087 (April 2, 1993).

2. *Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants*, Rev. 1, RG 1.21, U. S. Nuclear Regulatory Commission (June 1974).

3. *Pressurized Water Reactor Primary Water Chemistry Guidelines*, Volume 1, Rev. 6, EPRI (December 2007).

4. Letter from Yoshiki Ogata, MHI, to NRC dated May 14, 2009; Docket No. 52-021, MHI Ref: *UAP*-HF-09241; Subject: MHI's Response to US-APWR DCD RAI No. 294-2129 Revision 1 (ADAMS Accession No. ML091380162).

5. Letter from Yoshiki Ogata, MHI, to NRC dated September 28, 2009; Docket No. 52-021, MHI Ref: UAP-HF-09461; Subject: MHI's Response to US-APWR DCD RAI No. 448-*3469* Revision 1 (ADAMS Accession No. ML092730189).

6. Letter from Yoshiki Ogata, MHI, to NRC dated October 28, 2009; Docket No. 52-021, MHI *Ref*: UAP-HF-09499; Subject: Transmittal of the Updated Chapter 14 of US-APWR DCD (ADAMS Accession No. ML093070291).

7. Letter *from* Yoshiki Ogata, MHI, to NRC dated April 7, 2010; Docket No. 52-021, MHI Ref: UAP-HF-10075; Subject: MHI's Response to US-APWR DCD RAI No. 526-4121 Revision 2 (ADAMS Accession No. ML101020018).

9.3.3 Equipment and Floor Drainage System

9.3.3.1 Introduction

The equipment and floor drainage systems (EFDS) collect liquid waste from equipment and floor drains during all modes of operation and separate the contaminated effluents and transfers them to the processing and disposal systems. Equipment and floor drainage is classified and segregated by the type of waste generated. Liquid waste classification includes:

- Radioactive liquid waste.
- Non-radioactive liquid waste.
- Chemical and detergent liquid waste.
- Oily liquid waste.

9.3.3.2 Summary of Application

DCD Tier 1: The DCD Tier 1 information associated with this section is found in Tier 1, Section 2.7.6.8 of the US-APWR DCD.

FSAR Tier 2: The applicant has provided a Tier 2 description of the EFDS in Section 9.3.3 of the US-APWR DCD.

ITAAC: The ITAAC associated with the EFDS are given in DCD Tier 1, Section 2.7.6.8 and Table 2.7.6.8-1.

Preoperational Testing: The preoperational test associated with the EFDS is given in DCD Tier 2, Section 14.2.12.1.116.

9.3.3.3 Regulatory Basis

The staff reviewed the EFDS described in the US- APWR DCD, Revision 3, in accordance with NUREG-0800, “Standard Review Plan [SRP] for the Review of Safety Analysis Reports for Nuclear Power Plants,” Section 9.3.3, “Equipment and Floor Drainage System,” Revision 3, March 2007.

The acceptance criteria for the design for the EFDS are:

- General Design Criteria (GDC) 2, “Design Bases for Protection Against Natural Phenomena,” as to safety-related system portions capable of withstanding the effects of natural phenomena.

- GDC 4, “Environmental and Dynamic Effects Design Bases,” as to capability to withstand the effects of and to be compatible with the environmental conditions (flooding) of normal operation, maintenance, testing, and postulated accidents (pipe break, tank ruptures).

- GDC 60, “Control of Releases of Releases of Radioactive Material to the Environment,” as to suitable control of the release of radioactive materials in liquid effluent, including AOOs. This criterion applies as the EFDS usually consists of two subsystems, radioactive and nonradioactive. The inadvertent transfer of radioactive wastes to the nonradioactive portion of the system could result in radioactive releases to the environment.

- 10 CFR 52.47(b)(1), which requires that a DC 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 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.

9.3.3.4 Technical Evaluation

The staff reviewed the EFDS described in the US- APWR DCD, Revision 3, in accordance with NUREG-0800, Section 9.3.3, Revision 3, March 2007.

GDC 2

GDC 2 acceptance is based on the safety-related portions of the system being able to withstand the effect of natural phenomena (such as seismic event, floods, etc.) without loss of capability to perform safety functions. As a part of GDC 2 review, the staff reviewed the applicant's determination of the "safety-related" portions of the system.

The staff reviewed the application in accordance with the guidance of SRP Section 9.3.3, Subsection III, to verify the adequacy of the applicant's determination of those portions of the EFDS being safety-related. Section 9.3.3 of the DCD Tier 2 identifies the isolation valves in the drainage piping from engineered safety feature (ESF) equipment rooms as the only safety-related EFDS components. The drain systems from ESF equipment rooms are designed to prevent flooding due to backflow by virtue of a difference in elevation of the ESF equipment rooms and the collection sump. Additionally, isolation valves are provided on the ESF equipment rooms drainage piping in order to protect against flooding due to backflow. The staff confirmed in Table 3.2-2, "Classification of Mechanical and Fluid Systems, Components, and Equipment," of the DCD that these isolation valves are designed as Seismic Category I, Equipment Class 3, Quality Group C. Therefore, the staff finds Seismic Category I determination for the valves in the drainage piping from ESF rooms satisfies RG 1.29 "Seismic Design Classification," Position C.1 for the safety-related components.

Determination of Safety-related Portions of the EFDS

To complete the evaluation of DCD Section 9.3.3, the staff reviewed the EFDS to determine if components should be classified as safety-related.

The staff reviewed Figure 9.3.3-1, "Equipment and Floor Drain System Flow Schematics," and found that it did not contain sufficient details to confirm the equipment class and quality group for all of the EFDS components. Further, the staff found inadequate piping (flow paths and connections) and instrumentation in Figure 9.3.3-1. Some details that were not included in EFDS Figure 9.3.3-1 are containment penetration piping, containment isolation valves, leak detection and level instrumentation may perform a safety-related function. **RAI 299-2036, Question 09.03.03-1** requested the applicant to provide piping and instrumentation diagrams (P&IDs) or drawings with sufficient details.

The applicant responded to RAI 299-2036, Question 09.03.03-1, dated May 14, 2009, explaining that the transfer line from the containment vessel (C/V) sump to the liquid waste holdup tank located outside the C/V, is included in the LWMS. These containment isolation valves and the containment penetration piping are listed as Item 15 in Table 3.2-2 and not Item 25. The staff reviewed the applicant's response and is satisfied that these components are defined as outside the scope of the EFDS review.

Consistent with RAI 299-2036, Question 9.3.3-1, dated May 14, 209, the applicant revised EFDS Figure 9.3.3-1 to show the leak detection instrumentation for the safeguard equipment area and the routing of transfer line from C/V sump, which includes the isolation valves discussed above. The staff reviewed these changes to the figure and finds that this revision resolved the issues; therefore, the staff considers RAI 299-2036, Question 09.03.03-1 to be closed.

In Table 3.2-2 under the components, “Drain piping valves related to ESF rooms drain isolation…,” the valves, “DS-VLV 001A through DS-VLV 002 and DS-VLV-100 through DS VLV-102,” needed to be clarified. “DS-VLV 001A through DS-VLV 002” were out of sequence and confusing. This clarification is noted in **RAI 299-2036, Question 09.03.03-2.**

The applicant response, dated May 14, 2009, included provisions to rephrase Item 25 in Table 3.2-2 to clearly list the safety-related valves. This was incorporated into Table 3.2-2 in Revision 2 of the DCD to define the ESF isolation valve as the only safety-related valve in the EFDS. The staff reviewed the valve references in the DCD and finds that it adequately addresses staff’s concern as described in RAI 299-2036, Question 09.03.03-2. Therefore, the staff considers RAI 299-2036, Question 09.03.03-2 to be closed. In addition, RAI 426-3167, Question 9.3.3-15, response limited the numbering for valves shown in DCD Figure 9.3.3-1 to the safety-related isolation valves, as addressed below.

Section 9.3.3 of the DCD referred to Figure 9.3.3-1 which shows buildings and their respective sumps, sump pumps, and isolation valves, which were included in the EFDS DCD Tier 2 description. However, the system description in Section 9.3.3.2 and Section 9.3.3.4.1, “Testing During Construction,” of the DCD did not list the C/V or the PS/B. **RAI 299-2036, Question 09.03.03-3 and RAI 299-2036, Question 09.03.03-12,** requested the applicant to include the C/V and PS/B in the system description and testing sections.

The applicant’s response to RAI 299-2036, Question 09.03.03-3, dated May 14, 2009, indicated that a reference to “C/V” and “PS/B” will be added to the paragraphs in Section 9.3.3.2 and Section 9.3.3.4.1 of the DCD. Based on the applicant’s update in Revision 2 of the DCD, the staff finds the concerns as described in RAI 299-2036, Question 09.03.03-3, and RAI 299-2036, Question 09.03.03-12, to be adequately addressed and, therefore, considers them to be resolved.

SRP Section 9.3.3 (III.1.A) states that if the EFDS is capable of detecting leaks in safety systems that utilize the drainage system sumps and is the only means for such detection, it is considered safety-related. Section 5.2.5.4.1.1 of the DCD states that unidentified leakage inside the containment from the RCPB and other components condense to liquid and are driven by gravity to the floor drains and are eventually routed to the C/V sump. The containment sump level and flow monitoring as described in DCD Section 5.2.5.4 is one of the several leakage detection methods. Based on the above review procedure, the staff concludes that the containment sump level and flow monitoring systems are not the sole means for leakage detection to ESF equipment rooms, and, therefore, non safety-related is the proper classification.

SRP Section 9.3.3 (III.1.B) states that if the system can result in the inundation of safety-related areas due to drain backflow from malfunction of active components, blockage, or the probable maximum flood, then it is safety-related in that area. The application stated that the isolation valves located in drainage piping in the ESF equipment rooms are safety-related because the isolation valves are used to prevent flooding in the ESF equipment rooms. However, the DCD did not explain how the isolation valves will function to prevent flooding. The applicant was asked to provide additional details on isolation signals, instrumentation and inadvertent operation of the isolation valves. **(RAI 299-2036, Question 09.03.03-4).**

The applicant's response, dated May 14, 2009, to RAI 299-2036, Question 09.03.03-4 explained that ESF equipment rooms have manually operated, normally closed isolation valves installed in drainage piping that will prevent flood water from entering the rooms from the floor drain as described in Section 3.4.1 "Flood protection." The applicant's response also stated that any flow-in water from access openings is prevented by water-tight doors. Since the isolation valves are manually operated and in a normally closed position, there is no instrumentation for operating and monitoring these isolation valves, and no way for them to re-open unintentionally. The only time these valves are used is when maintenance personnel need to open them to release detergent water from the room. Based on the applicant's response, dated May 14, 2009, the staff concludes that the concerns in RAI 299-2036, Question 09.03.03-4, are resolved in regard to the isolation valves. In accordance with SRP Section 9.3.3(III.1.B) guidance for determining safety-related components, the staff finds that no other EFDS component besides the ESF equipment room containment isolation valves is safety-related, with regard to the inundation of water.

Upon further review of DCD Section 9.3.3, the staff finds that the safety-related ESF equipment room isolation valves do not have any distinctive representation for being safety-related components and are only referred to as "isolation valves." In Section 9.3.3.2.2, the component description of these manually-operated valves also did not designate them as safety-related isolation valves. The staff requested in **RAI 426-3167, Question 09.03.03-15,** that all references to safety-related isolation valves be clearly distinguished from non-safety related valves in the DCD Section 9.3.3 and Figure 9.3.3-1. As a result of the RAI 426-3167, Question 09.03.03-15 response, dated September 14, 2009, the applicant revised Figure 9.3.3-1 to clearly define the isolation valves for the safeguard component areas as safety-related. Based on its review of the applicant's response, the staff concludes that the issues as described in RAI 299-2036, Question 09.03.03-4, and RAI 426-3167, Question 09.03.03-15, are resolved.

In reviewing the potential drain backflow of the EFDS in accordance with SRP Section 9.3.3 (III.1), the staff finds that DCD Section 9.3.3.1.1 stated that the drain system from ESF equipment rooms is designed to prevent flooding due to backflow by virtue of the difference in elevation between the ESF rooms and the collection sumps. The staff could not verify whether the EFDS is capable of preventing flooding simply by elevation without the use of check valves, because there is no information provided about the elevation of the rooms or other consideration of the design basis of the EFDS of the entire spectrum of flooding events. The applicant was requested to provide the above information to demonstrate that the EFDS design is capable of preventing flooding for the whole spectrum of flooding events simply by elevation. **(RAI 299-2036, Question 09.03.03-5).**

The applicant's response to RAI 299-2036, Question 09.03.03-5, dated May 14, 2009, referenced DCD Section 3.4.1.5.2.1 and explained that the ESF equipment below the maximum flood level is protected by water tight concrete rooms and all penetrations into the area are above the maximum flood level. Water can flood the basement without affecting any safety-related equipment. After review of the applicant's response and DCD Section 3.4.1.5.2.1, the staff concludes that the ESF equipment rooms are partitioned and designed to protect equipment from floods by virtue of elevation as described in DCD Section 3.4.1. Based on the applicant's response, the staff finds the concerns as described in RAI 299-2036, Question 9.03.03-5, to be adequately addressed and therefore, considers the issues to be resolved.

SRP Section 9.3.3 (III.1.d) states that if a failure or malfunction in a portion of the system could adversely affect safety-related (including accident mitigation) SSCs it is safety-related. Based on staff review, the ESF equipment room isolation valves could not fail and compromise the safety-related SSCs in the ESF equipment room. Therefore, the staff agrees with the applicant on its determination that the ESF equipment room isolation valves are safety-related. In addition, the staff reviewed other components connected to these safety-related isolation valves (e.g., drainage pipes, floor drains, sumps) that could possibly become blocked or otherwise fail. In this case, the applicant was requested to explain why the connecting components are not considered safety-related since their failure or malfunction could compromise the safety-related SSCs or prevent the safety-related isolation valves from performing their function. Furthermore, SRP Section 9.3.3, Section III.3.a states that the failure of any non-safety related portions of the system should not preclude the safe operation of the safety-related Seismic Category I EFDS portions. The DCD Section 9.3.3.1.2 "Power Generation Design Bases," stated that the ESF room floor drain systems and components are the only components designed to Seismic Category I. The staff requested the applicant to provide more details to explain how the failure of components that house and are in close proximity to the isolation valves will not adversely affect their safety function. **(RAI 299-2036, Question 09.03.03-7)**

The applicant's response to RAI 299-2036, Question 09.03.03-7, dated May 14, 2009, explained that any nonsafety-related components (such as drain piping, sump tanks and sump pumps) in the vicinity of safety-related components are designed as Seismic Category II, in that its failure will not adversely impact the function of the safety-related components. Additionally, the response indicated that sump pump failure will not adversely impact the safety-related valves because the sump pumps are redundant and are not credited to mitigate internal flooding. The safety-related components are protected by physical barrier or located away from possible sources of physical impacts (pipe whip, internal missile). The DCD has incorporated the above changes. Based on the applicant's response and the changes in DCD Section 9.3.3, the staff finds there is reasonable assurance that a failure of any non-safety related component will not adversely impact the function of the safety-related valves during a seismic event. Therefore, the staff considers RAI 299-2036, Question 09.03.03-7, to be closed. Although the isolation valves are safety-related, the staff was unable to determine whether the piping from these isolation valves into the safeguard component area is similarly classified as safety-related. Therefore, the applicant was asked in **RAI 591-4722, Question 9.3.3-18,** to provide the classification for the piping in question or define any potential failure scenarios that could impact the room as a result of failure of the non-safety piping portions and update the DCD accordingly. The applicant's response to RAI 591-4722, Question 9.3.3-18, dated July 7, 2010, clarified that a portion of the drainage piping from the safeguard components areas is embedded into the basemat and the portion of piping beyond the basemat, up to and including the safety-related valves is fully supported and restrained to minimize the potential for breaking. Hence the piping is non-safety and is Class 6. Based on the applicant's clarification, the staff concludes that the classification provided does not affect the safety function of the isolation valve and provides adequate protection against in-flow flooding of the ESF room. Therefore, the staff considers the concerns as described in RAI 591-4722, Question 9.3.3-18, to be resolved.

GDC 2 acceptance is based on the safety-related portions of the system being able to withstand the effect of natural phenomena such as flooding or a seismic event. Based on the above, the staff finds that the safety-related components of the EFDS are adequately defined and the system meets GDC 2.

GDC 4

GDC 4 acceptance is based on the system being able to prevent flooding that could adversely affect SSCs important to safety. SRP Section 9.3.3 Subsection II, “Acceptance Criteria,” clarifies the acceptance of GDC 4 for the EFDS. It states that for the EFDS the purpose of GDC 4 is to assure the capability to provide the required drainage capability to accommodate unanticipated flooding from pipe breaks, tank leaks, discharge from fire suppression systems, and other potential flooding sources. Therefore, the staff determined that the drainage capability of the EFDS for the flood protection should be addressed in the DCD Section 9.3.3 for EFDS to meet GDC 4 criterion. DCD Section 3.4.1, “Flood Protection,” Section 3.4.1.3, “Flood Protection from Internal Sources,” and Section 3.4.1.5, “Evaluation of Internal Flood Protection,” discuss the flood protection design to withstand the effects of and to be compatible with the internal flooding of normal operation, maintenance, testing, and postulated accidents (pipe break, tank ruptures). The staff reviewed DCD Section 9.3.3, in connection with Section 3.4.1, Section 3.4.1.3, and Section 3.4.1.5 and found that the EFDS has been used in the flood protection design as described in the above DCD sections. However, the staff could not find the information as related to the required drainage capability to accommodate unanticipated flooding from pipe breaks, tank leaks, discharge from fire suppression systems, and other potential flooding sources.

Based on the above review, the applicant was requested to: (1) clarify what drainage capability is assumed in the flood analysis, and to substantiate the assumption by calculations for flood analysis, which are not available in the DCD, (2) revise FSAR Section 9.3.3 to address GDC 4 compliance in accordance with SRP Section 9.3.3 regarding drainage capability and (3) if components are needed for flood protection, these components may need to be identified as being safety-related and subject to GDC 2 requirements. **(RAI 299-2036, Question 09.03.03-8).**

The applicant’s response, dated May 14, 2009, to RAI 299-2036, Question 09.03.03-8, stated that GDC 4 compliance, in accordance with SRP Section 9.3.3, regarding drainage capability is not required for EFDS. The response stated that safeguards equipment is protected from flooding effects by concrete walls and water-tight doors with individual drainage paths. The applicant cited DCD Section 3.4.1 regarding the elevation and design of ESF equipment rooms and relevant areas and the protected equipment is located in various elevations. As referenced in the RAI response, Section 3.4.1 describes in further detail how the safeguard component rooms are isolated by concrete walls and water-tight doors. In addition, the drains for these rooms are separated from outside floor drains which are reviewed in Section 3.6.1 of this document. Therefore, if water floods the surrounding area it will not impact the safeguard components located inside the concrete walls.

The applicant added a reference in DCD Tier 2 Section 9.3.3.1.1 referring to DCD Section 3.4 and Section 3.6 accordingly. Based on the applicant’s response and review of DCD Section 3.4 and Section 3.6, the staff finds the concerns as described in RAI 299-2036, Question 09.03.03-8, are adequately addressed and therefore, considers them to be resolved. Section 3.4 of the DCD adequately describes the drainage capability of the surrounding area and explains how elevation and design protects the safeguard equipment rooms from flooding. The flooding analysis is reviewed in Section 3.4.1 of this document.

SRP 9.3.3 Section I, “Areas of Review,” states that the EFDS is “designed to ensure that waste liquid, valve, and pump leak-offs, and tank drains are directed to proper areas for processing or disposal and that excessive water accumulation and flooding is prevented in accordance with plant design basis.” The applicant’s system description in the DCD did not explicitly identify prevention of flooding and water accumulation as an important EFDS function. **(RAI 299-2036, Question 09.03.03-9).**

As a result of the applicant's response to RAI 299-2036, Question 09.03.03-9, dated May 14, 2009, DCD Section 9.3.3.1.1 was updated to clarify the flooding prevention function for the EFDS, and the EFDS by its nature will function to prevent flooding and water accumulation for the volume being drained. Based on the DCD additional statement clarifying that flood prevention and water accumulation are key functions for the EFDS, the staff concludes that the issues as described in RAI 299-2036, Question 09.03.03-9, are considered to be resolved.

GDC 4 acceptance is based on the systems being able to prevent flooding that could adversely affect SSCs important to safety, as a result of pipe breaks, tank ruptures, and other postulated accidents. The applicant has shown that the ESF equipment is protected from flooding by concrete rooms equipped with individual floor drains and drainage paths with isolation valves as described in DCD Section 3.4. Based on the above review, the staff concludes that the EFDS meets GDC 4.

GDC 60

In order to meet GDC 60, the EFDS must be designed to control the release of radioactive material in liquid effluent, including operational occurrences by preventing the inadvertent transfer of contaminated fluids to a non-contaminated drainage system for disposal. Since the EFDS usually consists of both radioactive and nonradioactive subsystems, this criterion applies. The inadvertent transfer of radioactive wastes to the nonradioactive portion of the system could result in radioactive releases to the environment.

As stated in Section 9.3.3.1.2 of the DCD, the radioactive drainage system and non-radioactive drainage system are separated. However, in the case where radioactive water flows into a non-radioactive system (e.g. CCW component failure), potentially radioactive contaminants are diverted from the non-radioactive drainage system to the LWMS. This is in conformance with the requirement of GDC 60.

According to the SRP Section 9.3.3 Section III.1.C, "Review Procedures," a component is safety-related if it is connected in such a way that inadvertent contamination of non-radioactive portions of the EFDS can occur. The applicant stated that under normal operating conditions the TB sump's non-radioactive contents are routed to the waste water system (WWS) and, if the TB sump contents become contaminated, the contaminated fluid can be detected by radiation monitors, and diverted to the LWMS. During the review, the staff found that an inadvertent transfer of radioactive effluent is possible if the TB discharge valve fails to close. Also, if the radiation monitors fail, the TB sump discharge valve may not receive the proper signal to close. The staff requested the applicant to explain how the radiation monitors and the TB sump discharge valve will operate and prevent inadvertent contamination, with an active component failed. In addition, the staff also requested the applicant to discuss the radiation monitoring instrumentation in DCD Section 9.3.3.5, "Instrumentation Requirements." The applicant was requested to justify why the above components need not be classified as safety-related. **(RAI 299-2036, Question 09.03.03-10).**

In its RAI 299-2036, Question 09.03.03-10 response, dated May 14, 2009, provided an explanation of how the radiation monitor initiates an alarm in the MCR for operator action, turns off the TB sump pump, and closes the transfer valves if the monitor detects radiation above a predetermined setpoint. The applicant further stated that, after confirming the sump content, the operator can manually initiate a transfer of the fluid to either the WWS (if non-radioactive) or to the AB floor drain sump (if radioactive) from which it will be transferred to the LWMS for treatment. This monitor also initiates an alarm if the monitor has a malfunction and the monitor is periodically inspected and calibrated. The transfer valves located on the piping to the WWS and to the AB sump are set to fail close to further prevent cross contamination.

DCD Sections 9.3.3.1.2, 9.3.3.2.2 and 9.3.3.2.3 include details in the DCD on the monitoring and operation of the TB sump pump discharge valve. Based on its review, the staff finds that DCD Section 9.3.3 provides reasonable assurance of protection from an inadvertent transfer of radioactive fluid to the environment by the use of radiation monitoring, TB pump shutoff and transfer valves fail close features. Therefore, the staff considers the issues as described in RAI 299-2036, Question 09.03.03-10 to be resolved.

As a result of the RAI 299-2036, Question 09.03.03-10 response, the applicant revised the DCD to incorporate an explanation describing how the radiation detection instrumentation, transfer valves and flow paths work to prevent the inadvertent release of radioactive contaminants. However, the DCD revision failed to provide sufficient detail regarding operation of the two normally closed transfer valves that were added to the TB sump discharge in Figure 9.3.3-1. It was unclear in the figure whether normal operation would provide flow to the AB sump or outside the building and what method would be used to control the valve for proper configuration. Therefore, the staff asked for additional design information in **RAI 426-3167, Question 09.03.03-16**. The applicant provided its response, dated September 17, 2009 describing the operation of the transfer valves arrangement and included a revision to the configuration in the routing of the TB sump discharging into the AB sump in Figure 9.3.3-1 and Section 9.3.3.

In the RAI response, the proposed revision to Section 9.3.3.2.3 indicated that the diversion of normal flow discharging into the WWS switches automatically to flow into the LWMS in response to a radiation signal. However, the RAI 299-2036, Question 9.3.3-04 response indicated that rerouting flow is defined as a manual process. Therefore, the staff issued **RAI 591-4722, Question 09.03.03-19,** requesting the applicant to address this inconsistency. The applicant’s response to RAI 591-4722, Question 9.3.3-19, dated July 7, 2010, clarified that the diversion of flow from the TB Sump to the LWMS, instead of the WWS, does require operator initiation. As indicated above, the valves isolate and operator action is required in response to a radiation signal. Based on the response, the staff considers the concerns as described in RAI 426-3167, Question 09.03.03-16, and RAI 591-4722, Question 09.03.03-19, to be resolved.

DCD Section 9.3.3.1.2, “Power Generation Design Bases,” stated that no interconnections exist between the radioactive and non-radioactive portions of the system. During review of DCD Section 9.3.3 and Figure 9.3.3-1, it appeared that some portions of the radioactive EFDS are connected to non-radioactive portions. The discharge from TB sump appeared to be connected to both the waste hold-up tanks, which directly flow to the LWMS (radioactive portion of the EFDS) and to the non-radioactive WWS outside the TB. In addition, connections are shown between the non-radioactive RB sump and “Radioactive Area CCW Drains,” in Figure 9.3.3-1. The applicant was requested to clarify the above inconsistency with respect to the statement: “The systems are designed with no cross connection between the radioactive and non-radioactive drainages system…” (**RAI 299-2036, Question 09.03.03-11**).

The applicant’s response to RAI 299-2036, Question 09.03.03-11, dated May 14, 2009, explained that the EFDS includes separated subsystems for handling radioactive and potentially radioactive drainage and another for handling non-radioactive drainage. Potentially radioactive drainage from the C/V, RB, AB, and AC/B is collected separately in an equipment drain sump and a floor drain sump and sent from these sumps to the LWMS for treatment. Floor drains contain a higher concentration of suspended solids and may also contain solvents from maintenance and decontamination activities. Therefore, the drains are first collected in the floor drain sump for the removal of solids, sludge, and oily substances. As discussed above, the applicant further explained that, during normal operation, the non-radioactive liquid discharge from the TB sump is sent to the WWS for processing for re-use or release. If the TB drains become contaminated, the EFDS design provides the flexibility to send the TB drains to the LWMS for treatment, by means of the AB floor drain sump. This design minimizes the spread of radioactive contamination to the WWS. In addition, the applicant explained that the CCW drain shown in DCD Figure 9.3.3-1 contains non-radioactive fluid and is routed to the "R/B Non-Radioactive Sump."

Based on the response, the staff finds the concerns in RAI 299-2036, Question 09.03.03-11 to be adequately addressed and resolved. Since the transfer of non-radioactive fluids to LWMS is possible, the applicant removed the phrase which states that no cross connection between radioactive and non-radioactive systems exist by deleting a passage in DCD Section 9.3.3.1.2. The applicant has also updated Figure 9.3.3, which clearly labels the non-radioactive CCW drains.

Upon further staff review of the revised Figure 9.3.3-1, the floor drains located in the AB and RB buildings were not defined as radioactive or non-radioactive and were shown as draining into either the "R/B Sump" (Sheet 1 of 2) or the "R/B Non-Radioactive Sump" (Sheet 2 of 2) for each building. The applicant was requested in **RAI 426-3167, Question 09.03.03-17,** to provide justification for providing floor drains discharging into both radioactive and non-radioactive sumps in the same building, and discuss how radioactive waste is precluded from draining into non-radioactive sump. In its response to RAI 426-3167, Question 09.03.03-17, dated September 14, 2009, the applicant provided a detailed description on the routing and normal operation of the radioactive and non-radioactive drains. It was clarified that the radiological and non-radiological sumps are physically separated by floors and walls, and are located in different areas within the RB. The RB sumps in the radioactive controlled area (RCA) are located in the plant north, and the RB sumps in the non-radioactive controlled area are located in the plant south side of the RB. The applicant indicated that the design separates radioactive versus non-radioactive drains during normal operation and also provides detection and recycle capability to treat contaminated fluid in the event of equipment failure. The RCA sump is directly piped to the LWMS and thus, eliminates inadvertent transfer of radioactive waste to non-radioactive waste portions of the system. Based on the applicant clarification of the safe routing and normal operation of the radioactive and non-radioactive drains, the staff considers the concern as described in RAI 426-3167, Question 09.03.03-17 to be resolved.

GDC 60 requires the EFDS to be designed to control the release of radioactive material in liquid effluent, including operational occurrences by preventing the inadvertent transfer of contaminated fluids to a non-contaminated drainage system for disposal. Based on its review, the staff finds reasonable assurance to protect an inadvertent transfer of radioactive fluid to the environment by use of monitoring the TB pump shutoff and transfer valves' fail-closed features. Therefore, the staff finds EFDS meets GDC 60.

Initial Test Program

The staff reviewed Chapter 14 “Verification Programs,” of Tier 2 of the US-APWR DCD to ensure the applicant conformed to initial plant test (IPT) requirements. The initial test program for US-APWR is evaluated in Section 14.2 of this SE, and evaluation of the EFDS initial test program in this section is an extension of the evaluation provided in Section 14.2. Chapter 14 of the US-APWR DCD lists no requirement for the EFDS. RG 1.68, “Initial Test Programs for Water-Cooled Nuclear Power Plants” Appendix A, Item 1.n(9), identifies drain systems as one of the plant features required to have initial testing. Further, the staff found in DCD Table 14A-1 under Item 1.n(9), the applicant intends to address RG 1.68 Appendix A Item 1.n(9) under Section 14.2.12.1.80, “Liquid Waste Management System Preoperational Test.” This test focuses on the LWMS and the staff was unable to locate IPT for the EFDS. The applicant was requested to include the test for all the important SSCs associated with EFDS. **(RAI 243-2044, Question 14.02-109)**

As a result of the RAI response, dated March 27, 2009, the applicant revised Table 14A-1 of the DCD to include EFDS initial testing. The new test of the floor drains and sump systems will use water addition or pressurized air as appropriate to show the proper functioning of the drain piping and valves used to prevent cross-divisional flooding. Table 14.2-1 includes a new Section 14.2.12.1.116, “Equipment and Floor Drainage System Preoperational Test” as recommended in guidance of RG 1.68.

In reviewing the potential blockage of the EFDS in accordance with SRP Section 9.3.3, Review Procedure (III.1.B), the staff found that DCD Section 5.2.5.7 states that periodic inspection of the floor draining system to the containment sump is conducted to check for blockage and ensure unobstructed pathways. However, the staff found this inspection as described in DCD Section 5.2.5.7 was limited to the floor drain to the containment sump only. The applicant was requested to address the potential blockage of floor drains to all the other sumps in the EFDS. **(RAI 299-2036, Question 09.03.03-6).**

The applicant’s response to RAI 299-2036, Question 09.03.03-6, dated May 14, 2009, indicated that DCD Section 9.3.3.4.1 will be revised to add a statement referring to a new preoperational test in Section 14.2.12.1. The applicant described that after performing the testing during construction, the formal testing of the EFDS is unnecessary since the operability and integrity of this system is checked during normal periodic inspections. Based on the applicant’s response and update of the DCD, the staff considers the concern as described in RAI 299-2036, Question 09.03.03-6, to be resolved.

The objective of the EFDS new preoperational test program was found to be appropriate since it is to demonstrate the capability of the EFDS to provide the correct routing and demonstrate operation of instrumentation and alarms. The testing also ensures that the RB floor drain and sump systems operation demonstrates that the system piping and valves prevent backflow to prevent cross-divisional flooding between areas, The results of the EFDS test program are considered to be acceptable if the EFDS perform as described in Tier 2, DCD Section 9.3.3

The additional preoperational test in Section 14.2.12.1.116 of the DCD is described in the applicant’s response to RAI 243-2044, Question 14.02-109 above. Based on the applicant’s response to RAI 299-2036, Question 09.03.03-6 and RAI 243-2044, Question 14.02-109, dated March 27, 2009, the staff concludes that the addition of the new preoperational test for the EFDS addresses the RB, C/V, AB drain initial test program.

Inspections, Tests, Analyses and Acceptance Criteria (ITAAC)

Tier 1 of the DCD Section 2.7.6.8, “Equipment and Floor Drainage Systems,” contains a description of the EFDS and includes ITAAC in DCD Tier 1, Table 2.7.6.8-1. The equipment and floor drainage systems are non safety-related systems with the exception of the isolation valves in the drainage piping from ESF equipment rooms. Table 2.7.6.8-1 contains design commitments to ensure the safety-related isolations valves are built according to ASME Code standards with corresponding ITAAC.

As specified in Tier 1, Section 2.7.6.8, the drain systems from ESF equipment rooms are designed to detect a flooded condition and to prevent flooding due to backflow by the virtue of a difference in elevation of the ESF equipment rooms and the collection sump. A common alarm in the MCR is provided for indication of a flooded condition. Figure 2.7.6.8-1 is included to show the safety-related portions of the EFDS in order to complete ITAAC to verify functional arrangement.

The ITAAC are specified in Table 2.7.6.8-1 in the DCD. This section of the staff’s evaluation confirms that the appropriate ITAAC are specified for the EFDS consistent with the approach that is described in Tier 2, DCD Section 14.3.

The staff concludes that if the ITAACs for ECWS are performed and the acceptance criteria met, there is reasonable assurance the DC is built and will operate in accordance with the DC, the provision of the Atomic Energy Act of 1954, and the NRC’s regulations which includes 10 CFR 52.47 (b)(1).

9.3.3.5 Combined License Information

The staff found no COL information items in DCD Tier 2, Section 9.3.3.

9.3.3.6 Conclusions

The NRC staff has concluded that sufficient information has been provided by the applicant in the US-APWR DCD Tier 1 Section 2.7.6.8 and Tier 2 Section 9.3.3. In addition, the staff has compared the design information in the DCD application to the relevant NRC regulations, acceptance criteria defined in NUREG-0800, Section 9.3.3, and other NRC RGs. In conclusion, the US-APWR design for the EFDS is acceptable and meets the requirements of GDC 2, 4, and 60 and the guidelines of SRP Section 9.3.3 for controlling and monitoring of releases of radioactive materials to the environment.

9.3.4 Chemical and Volume Control System

9.3.4.1 Introduction

The purpose of the chemical and volume control system (CVCS) is to maintain the coolant inventory of the RCS and to provide chemical and radioactive cleanup of the RCS. Some components of the CVCS, such as the containment isolation valves, are safety-related, while other CVCS components, such as those associated with the boron recycle system, are non-safety related.

9.3.4.2 Summary of Application

DCD Tier 1: The Tier 1 information associated with this section is found in DCD Tier 1, Section 2.4.6.

DCD Tier 2: The applicant has provided a Tier 2 description of the CVCS in Section 9.3.4 of the US-APWR DCD, summarized here in part, as follows:

> The CVCS performs the following functions: (1) maintains the coolant inventory in the RCS for all modes of operation; (2) provides seal water flow to the RCS pumps; (3) provides makeup capability for small RCS leaks; (4) regulates the boron concentration in the reactor coolant during normal operation; (5) controls the reactor coolant water chemistry; (6) performs purification by removal of the fission and activation products in the reactor coolant; (7) borates the RCS for cold shutdown; and (8) provides pressurizer auxiliary spray water for depressurization of the RCS when none of the RCS pumps are operating.
>
> The CVCS performs the following safety functions: (1) provides RCPB; (2) provides containment isolation of CVCS lines penetrating containment; (3) provides capability for isolation of the charging line upon safety injection signal and high pressurizer water level; and (4) provides isolation capability for a boron dilution source in the reactor coolant to prevent inadvertent RCS boron dilution.
>
> The CVCS consists of charging pumps, regenerative HX, letdown HX, excess letdown HX, demineralizers, filters, pumps, tanks, and associated valves, piping, and instrumentation. The system parameters are given in Table 9.3.4-2. The key equipment parameters for the CVCS components are given in Table 9.3.4-3. The piping and instrumentation diagram is included in Figure 9.3.4-1.

ITAAC: The ITAAC associated with DCD Tier 2, Section 9.3.3 are given in DCD Tier 1, Section 2.4.6.2.

TS: The TS associated with DCD Tier 2, Section 9.3.4 are given in DCD Tier 2, Chapter 16, Section 3.6.3, Containment Isolation Valves. In addition, related TS 3.4.16 deals with the reactor coolant specific activity.

9.3.4.3 Regulatory Basis

The relevant requirements of the Commission regulations for this area of review, and the associated acceptance criteria, are given in Section 9.3.4 of NUREG-0800 and are summarized below. Review interfaces with other SRP sections can be found in Section 9.3.4.I of NUREG-0800.

1. GDC 1, “Quality Standards and Records,” of Appendix A to 10 CFR Part 50, as it relates to system components being assigned quality group classifications and application of quality standards in accordance with the importance of the function to be performed.

2. GDC 2, “Design Bases for the Protection Against Natural Phenomena,” as it relates to structures housing the facility and the system itself being capable of withstanding the effects of earthquakes.

3. GDC 5, “Sharing of Structures, Systems and Components,” as it relates to shared systems and components important to safety being capable of performing required safety functions.

4. GDC 14, “Reactor Coolant Pressure Boundary,” as it relates to assuring RCPB material integrity by means of the CVCS being capable of maintaining RCS water chemistry necessary to meet RCS water chemistry TS.

5. GDC 29, “Protection Against Anticipated Operational Occurrences,” as it relates to the reliability of the CVCS to provide negative reactivity to the reactor by supplying borated water to the RCS in the event of AOOs, if the plant design relies on the CVCS to perform the safety function of boration for mitigation of design basis events.

6. GDC 33, “Reactor Coolant Makeup,” and GDC 35, “Emergency Core Cooling,” as they relate to the CVCS capability to supply reactor coolant makeup in the event of small breaks in the RCPB, to function as part of the ECCS assuming a single active failure coincident with the LOOP, and to meet ECCS TS, if the plant design relies on the CVCS to perform the safety function of safety injection as part of the ECCS.

7. GDC 60, “Control of Releases and Radioactive Materials to the Environment,” and GDC 61, “Fuel Storage and Handling and Radioactivity Control,” as they relate to CVCS components having provisions for venting and draining through closed systems.

8. 10 CFR 50.34(f)(2)(xxvi), with respect to the provisions for a leakage detection and control program to minimize the leakage from those portions of the CVCS outside of the containment that contain or may contain radioactive material following an accident.

9. Paragraph (a)(2) in 10 CFR 50.63, “Loss of All Alternating Current Power,” as it relates to the ability of the CVCS to provide sufficient capacity and capability to ensure that the core is cooled in the event of a SBO.

10. 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.

Acceptance criteria adequate to meet the above requirements are:

1. The CVCS safety-related functional performance should be maintained in the event of adverse environmental phenomena such as earthquakes, tornadoes, hurricanes, and floods, or in the event of certain pipe breaks or LOOP.

2. The requirements of GDC 1 regarding the quality standards are met by acceptable application of quality group classifications and application of quality standards as described in RG 1.26. The requirements of GDC 2 are met by meeting the guidance of RG 1.29, Position C.1, for safety-related portions of the system and Position C.2 for non-safety related portions.

3. The requirements of GDC 5 would be met by the use of a separate CVCS for each unit.

4. For compliance with GDC 14, the CVCS should maintain acceptable purity levels in the reactor coolant through the removal of insoluble corrosion products, and dissolved ionic material by filtration and ion exchange. In addition the CVCS should maintain proper RCS chemistry by controlling total dissolved solids, pH, oxygen concentration, and halide concentrations within acceptable ranges.

5. For compliance with GDC 29, GDC 33, and GDC 35, the CVCS should provide sufficient pumping capacity to supply borated water to the RCS, maintain RCS water inventory within the allowable pressurizer level range for all normal modes of operation, and function as part of the ECCS, if so designed, to supply reactor coolant makeup in the event of small pipe breaks assuming a single active failure coincident with the LOOP. Also, RG 1.155 describes a means acceptable to the NRC staff for meeting the requirements of 10 CFR 50.63. If the CVCS is necessary to support a plant SBO coping capability as required by 10 CFR 50.63, the positions in RG 1.155 regarding CVCS design provide an acceptable method for showing compliance.

6. SECY-77-439 describes the concept of single failure criteria and the application of the single failure criterion that involves a systematic search for potential single failure points and their effects on prescribed missions.

7. The CVCS design and arrangement should be that all components and piping that can contain BA will either be heat traced or will be located within heated rooms to prevent precipitation of BA.

8. 10 CFR 50.34(f)(2)(xxvi), as applicable, specifies the provisions regarding detection of reactor coolant leakage outside containment. These requirements will be met, in part, by providing leakage control and detection systems in the CVCS and implementation of appropriate leakage control program.

9. Implementation Action 1 specified in Bulletin 80-05 provides an acceptable means for the system to prevent the CVCS holdup tanks, which can contain radioactive liquids and gases, from the formation of vacuum conditions that could cause wall inward buckling and failure. The requirements of GDC 60 and GDC 61 can be met, in part, by providing in the CVCS appropriately designed venting and draining closed systems to confine radioactivity associated with the effluents.

9.3.4.4 Technical Evaluation

9.3.4.4.1 Materials and Chemistry Aspects

The staff reviewed DCD Section 9.3.4 using the guidance of SRP Section 9.3.4. This SRP mentions the EPRI report "PWR Primary Water Chemistry Guidelines," as the standard by which water chemistry should be judged. Although the staff does not formally review or issue a safety evaluation of the various EPRI water chemistry guidelines (including the PWR Primary Water Chemistry Guidelines), the guidelines are recognized as representing industry best practices in water chemistry control. Extensive experience in operating reactors has demonstrated that following the EPRI guidelines minimizes the occurrence of corrosion-related failures. Further, the EPRI guidelines are periodically revised to reflect evolving knowledge with respect to best practices in chemistry control. Therefore, the staff accepts the use of the EPRI PWR Primary Water Chemistry Guidelines as a basis for a recommended primary water chemistry program for a standard reactor design.

9.3.4.4.1.1 RCS Coolant Chemistry

The purification of RCS water is accomplished through letdown flow through demineralizers and filters. This system is described in detail in DCD Section 9.3.4.2 and Tables 9.3.4-2 and 9.3.4-3. Two mixed bed demineralizers are present. However, only one is used during normal operation. This allows one to be held in reserve in case performance of the first diminishes. Each demineralizer is designed to contain sufficient resin to last for an entire fuel cycle. The specified flow rate through a single demineralizer is 180 gpm (0.0114 m^3/s), which implies that on average, the entire RCS volume of 83,800 gal. (317 m^3) flows through the purification system in slightly under eight hours. In addition, a cation bed demineralizer is provided for constant or intermittent use at lower flow rate of 110 gpm (0.00694 m^3/s); its purpose is to remove Litium (LI) and Cesium (Cs). The staff finds the system adequate to control concentrations of impurities and additives in RCS water.

Reactor coolant chemistry is also covered in SRP Section 5.2.3, where the primary concern is the compatibility of construction materials with the coolant. This subject is discussed in greater detail in Section 5.2.3 of this SE, where it is established that materials of construction are compatible with primary system coolant, provided that adequate water chemistry control occurs. Primary water chemistry control is the subject of both, Section 9.3.4 and Section 5.2.3.

Limits for constituents in coolant are shown in Table 9.3.4-1, and are identical to those in Table 5.2.3-2 (except that Fe, Si, and Zn are omitted in Table 9.3.4-1). Thus, the pH and impurity limits in the RCS are fully consistent with the EPRI Guidelines, as explained in more detail in Section 5.2.3, and to be verified by confirmatory items in Section 5.2.3.

Control of pH is achieved by regulating the inventory of LiOH. Concentrated solution is prepared in a chemical mixing tank, from which direct addition to RCS water is arranged. This method of pH control is widely used in operating reactors. In its response to RAI 350-2675 Question 05.02.03-17 (Reference 2), dated June 18, 2009, the applicant has supplemented DCD material with additional information explaining pH limits, noting that Table 5.2.3 is to be taken at 25 °C, and describes testing, startup, and other non-standard conditions. On the other hand, Table 9.3.4-1 describes pH limits during normal operation at RCS operating temperature (about 285 °C). In addition, the applicant has described a modified regime for pH control, as described in the EPRI Guidelines. This issue is also addressed more fully in Section 5.2.3. A reference to Figure 5.2.3-1, dated June 18, 2009, which shows the modified pH regime with clarifications in response to RAI 350-2675, Question 05.2.03-17, has been added to Section 9.3.4.2.3.2 in Revision 2 of the DCD. The staff finds the applicant's response to RAI 350-2675, Question 05.02.03-17 acceptable because the applicant provided clarifying information on the control of RCS pH, sufficient to allow the staff to conclude the pH will be adequately controlled to support RCS materials integrity.

At plant startup, hydrazine is injected into the RCS to scavenge oxygen. However, during normal operation, free oxygen is controlled by supplying hydrogen gas, which reacts with oxygen to form water. This reaction is catalyzed by radiolysis products which are abundant in the coolant as it passes through the core region. It is important to note that the reverse reaction (i.e., the separation of water into H_2 and O_2 molecules) is also catalyzed by radiation. Thus, the success of this method in reducing free oxygen depends on providing an excess amount of hydrogen. Hydrogen is supplied to the coolant by maintaining a gas space of H_2 in the volume control tank (VCT), which is downstream of the demineralizers. Water is re-injected into the RCS directly from this tank. By maintaining hydrogen concentrations as specified in Table 9.3.4-1, the concentration of oxygen in the RCS is sufficiently low to protect materials from oxidative degradation.

9.3.4.4.1.2 Borated Water Chemistry

BA is initially present in the RCS for reactivity control, and its concentration is gradually reduced over the course of a fueling cycle. The inventory of BA is monitored and maintained by the CVCS using additional equipment. DCD Table 9.3.4-3, indicates that all internals in contact with BA solutions or RCS coolant are stainless steel. If needed, the BA concentration in the RCS is increased by supplying BA solution to the VCT or to the charging pumps that inject VCT water back into the RCS. If the RCS inventory needs to be lowered, then unborated makeup water is supplied to the VCT or charging pump.

Concentrated boric acid solution (7000 ppm B = 4.0 wgt. percent H_3BO_3) is mixed and stored in two storage tanks. The DCD does not provide details of the mixing procedures or steps taken to ensure that precipitation does not result. In its response to RAI 280-2060, Question 09.03.04-1 (Reference 4), dated April 14, 2009, the applicant has provided additional information explaining this process, which is summarized as follows. BA solution is prepared in a heated batching tank from BA powder and demineralized water. The solution is then transferred to the BA storage tank, where it is mixed periodically using a recirculating pump. According to the applicant's response to RAI 380-2914, Question 09.03.04-8 (Reference 5), dated June 29 2009, both the batching tank and storage tank are sampled periodically to check the concentration of BA and impurities. Also in this RAI response, the applicant noted that Table 9.3.2-6 of the DCD will be altered to include sampling for SO_4 impurity. This change was incorporated in Revision 2 of the DCD. The staff finds that this plan will preclude precipitation, ensure adequate mixing, and limit impurity concentrations of BA solutions.

The BA storage tanks and associated equipment (piping, pumps, filters, blender, etc.) are to be maintained at 65 °F to prevent precipitation. In its response to RAI 280-2060, Question 09.03.04-1 (Reference 4), dated April 14, 2009, the applicant states that a low-temperature alarm is set at 70 °F (21.1 °C) to provide an early indication and initiate corrective heating. The authoritative compendium, Linke, *Solubilities* (Reference 6), indicates that the solubility limit for BA at 65 °F (18.3 °C) is 4.49 percent. This suggests that a 4 percent solution at this temperature is close to its solubility limit, and it is possible that inadvertent cooling could result in precipitation. However, if the concentrations and temperature are monitored as the applicant has specified, no precipitation should result. The staff therefore finds the responses to RAI 280-2060, Question 09.03.04-1, to be acceptable because adequate temperature controls to prevent precipitation are provided.

Boron Recycle

Water discharged from various sources within the RCS is sent to a holdup tank to await reprocessing by evaporation to produce distilled water and concentrated BA solution. The applicant has explained the evaporation process in more detail in response to RAI 280-2060, Question 09.03.04-4 (Reference 4). Water first passes through a demineralizer (to remove Li and radioactive ions), then to an evaporator where concentration occurs. The evaporator operates as a batch process. The holdup tank supplying evaporator feed is sampled and a volume is preselected to be fed into the evaporator so as to result in a final concentration of 7000 ppm B. After processing, the concentrated solution is then transferred to the BA storage tank for reuse.

The evaporator removes most dissolved gasses, including H_2 and gaseous fission products, and produces distilled water which may be re-used as makeup water or discharged as waste. Because every nonvolatile component will be concentrated, the removal of impurities by the demineralizer is important. In its response to RAI 280-2060, Question 09.03.04-3 (Reference 4), dated April 14, 2009, the applicant stated that grab sample points are located both upstream and downstream of the demineralizer; hence, impurity concentrations can be effectively monitored. In addition, the applicant has verified in its response to RAI 280-2060, Question 09.03.04-4 (Reference 4), dated April 14, 2009, that the concentrate from the evaporator is sampled for impurities and proper BA concentration. Finally, evaporation occurs at a fairly high temperature, and care must be taken to assure that precipitation does not occur when solutions are cooled in piping or equipment. The applicant has indicated in its response to RAI 280-2060, Question 09.03.04-1 (Reference 4), dated April 14, 2009, that the piping containing concentrate is heat-traced to preclude precipitation. Thus, the staff finds that applicant's plan for recycling BA solution ensures that the BA concentration is as intended and impurity concentrations are within specified limits.

Boron Dilution

Under normal operation, makeup of dilute borate solution (makeup water mixed with concentrated borate solution) is prepared and injected in an automatic mode. However, as described in response to RAI 280-2060, Question 09.03.04-5 (Reference 4), the operator can override the automatic system and inject borated solution or makeup water manually. In this case, all quantities are manually preselected by the operator and monitored during the injection operation. If makeup water injection exceeds a predetermined setpoint, then an alarm sounds and isolation valves close to end the operation. This ensures that undue or accidental dilution of the BA level in the RCS does not occur and the applicant's response is, thus, acceptable.

Worker Safety

Since the BA system provides reactivity control, GDC 21 requires that it be designed to facilitate periodic testing even during reactor operation. Furthermore, SRP 9.3.4 (Areas of Review 4) requires this review to ensure the adequacy of the system design to allow personnel access considering the effects of toxic, irritating, or explosive chemicals. In its response to RAI 280-2060, Question 09.03.04-6 (Reference 4), dated April 14, 2009, the applicant described the dangers of chemicals used in the CVCS system. It also summarized the locations and procedures for handling these chemicals. Storage areas are separate from the main reactor facility and are well-ventilated and protected. Preparation is done in the AB or RB, in tanks that can be sampled, and according to established procedures for handling these materials. These areas are equipped with radiation monitors to ensure worker protection. Thus, the staff concludes that appropriate safety measures are in place to satisfy regulatory requirements.

9.3.4.4.2 Leakage Monitoring and Prevention Program

SRP Section 9.3.4 includes among the regulatory criteria 10 CFR 50.34(f)(2)(xxvi), which, as applicable, specifies the provisions regarding detection of reactor coolant leakage outside of the containment. SRP Section 9.3.4 further states that these requirements will be met, in part, by providing leakage control and detection systems in the CVCS and implementation of appropriate leakage control program. In its response to RAI 346-2641, Question 09.03.02-10 Item 2, dated June 8 2009, the applicant indicated that the CVCS does not perform an ECCS function and is not expected to contain radioactive material following an accident. The applicant further indicated that the CVCS can be used following an accident, but this system is not operated when high containment radiation levels exist, and that the leak detection design provided for the system can appropriately detect the leakage when the system is used. In its response to RAI 461-3686, Question 09.03.02-12 Item 4, dated November 17, 2009, the applicant clarified that the CVCS is included within the scope of the leakage monitoring and prevention program. The staff finds this response acceptable because the addition of the CVCS and GWMS to the in-scope systems listed in TS 5.5.2 makes the list of in-scope systems consistent with the recommended in-scope systems from NUREG-0737 Item III.D.1.1. However, the "leakage detection design" for the CVCS mentioned in the response to RAI 346-2641 Question 09.03.02-10 Item 2 is not described in DCD Section 9.3.4. In addition, DCD Tier 2 Section 9.3.4.3 states "The CVCS does not provide an ECCS function. Therefore, the provision for a leakage detection and control program in accordance with 10 CFR 50.34 (f)(xxvi) does not apply." Therefore, in RAI No. 526-4121, Question 09.03.02-15, the staff requested the applicant to provide more detail on the leakage detection system for the CVCS, and to remove the statement from the DCD that the CVCS is not in scope of 10 CFR 50.34 (f)(xxvi). In its response to RAI No. 526-4121, Question 09.03.02-15, dated April 7, 2010, the applicant deleted the statement in the DCD, "Therefore, the provision for a leakage detection and control program in accordance with 10 CFR 50.34 (f) (xxvi) does not apply" (this is Confirmatory Item 09.03.02-15). The applicant also stated that the leakage detection system for the CVCS considers the possibility of large leakage from tanks in the CVCS. The applicant further indicated that the leakage detection system design uses level switches inside a slightly sloped drain pipe to ultimately determine leakage rate and allow for plant operators to perform analysis before corrective actions are implemented. The staff, thus, finds it acceptable because it lets the operator know if there is a leakage in the system and the rate of the leakage.

The leakage monitoring and prevention program is outlined in DCD Chapter 16, TS 5.5.2. A detailed evaluation of the compliance of the leakage monitoring and prevention program with 10 CFR 50.34(f)(2)(xxvi) and NUREG-0737 Item III.D.1.1, may be found in Section 9.3.2.3.3 of this report.

9.3.4.5 Combined License Information Items

There are none identified in the US-APWR DCD for Section 9.3.4.

9.3.4.6 Conclusions

Materials and Chemistry Aspects

The applicant has demonstrated that concentrations of impurities and added chemicals in RCS water are controlled consistent with EPRI Guidelines, and hence, satisfy the requirements of GDC 14. In addition, borated water is regulated in the RCS and auxiliary systems consistent with EPRI Guidelines and with good engineering practice, thereby satisfying the requirements of GDC 29. Thus the staff concludes that all regulatory criteria have been met.

The staff concludes the CVCS has design features that support compliance with 10 CFR 50.34 (f)(2)(xxvi) and NUREG-0737 III.D.1.1 with respect to a leakage monitoring and prevention program.

9.3.4.7 References

1. *Pressurized Water Reactor Primary Water Chemistry Guidelines*, Volume 1, Revision 6, EPRI (December, 2007).
2. Letter from Yoshiki Ogata, MHI, to NRC dated June 18, 2009; Docket No. 52-021, MHI Ref: UAP-*HF*-09329; Subject: MHI's Response to US-APWR DCD RAI No. 350-2675 Revision 1 (ADAMS Accession No. ML091730393).
3. Letter *from* Yoshiki Ogata, MHI, to NRC dated March 24, 2009; Docket No. 52-021, MHI Ref: UAP-HF-09123; Subject: MHI's Response to US-APWR DCD RAI No. 224-2067 Revision 1 (ADAMS Accession No. ML090850231).
4. Letter from Yoshiki Ogata, MHI, to NRC dated April 14, 2009; Docket No. 52-021, MHI Ref: UAP-HF-09171; Subject: MHI's Response to US-APWR DCD RAI No. 280-2060 Revision 1 (ADAMS Accession No. ML091060217).
5. Letter from Yoshiki Ogata, MHI, to NRC dated June 29, 2009; Docket No. 52-021, MHI Ref: *UAP*-HF-09349; Subject: MHI's Response to US-APWR DCD RAI No. 380-2914 Revision 1 (ADAMS Accession No. ML091820432).
6. W. F. *Linke*, *Solubilities*, 4th Ed., D. Van Nostrand Co., Inc., Princeton NJ (1958).

9.4 Air Conditioning, Heating, Cooling, and Ventilation Systems

9.4.1 Main Control Room Heating, Ventilation, and Air Conditioning System (Related to RG 1.206, Section C.III.1, Chapter 9, C.I.9.4.1, "Control Room Area Ventilation System")

9.4.1.1 Introduction

The US-APWR indicates that the control room area ventilation system is designed to provide proper environment in the MCR and other areas within the MCR envelope as defined in DCD Section 9.4.1, "Main Control Room Heating, Ventilation and Air Conditioning [MCR HVAC] System." This MCR HVAC system enables MCR personnel to remain safely inside the MCRE and take actions necessary to manage and control the plant under normal and abnormal plant conditions, including a LOCA and SBO. The MCREconsists of the MCR, operator area, shift supervisor office, clerk room, tagging room, toilet and kitchen. The MCR HVAC system complies with 10 CFR 50, Appendix A, GDC 2, 4, 5, 19, 60 and 10 CFR 50.63 and 10 CFR 52.47(b)(1).

The MCR HVAC system is shown in Figure 9.4.1-1 of the DCD and system equipment and components design data are presented in Table 9.4.1-1. The MCR HVAC system consists of two redundant 100 percent emergency filtration units and four 50 percent capacity air handling units, two 100 percent toilet/kitchen exhaust fans, one 100 percent smoke purge fan, ductwork, associated dampers and I&C. The AHUs are connected to a common overhead air distribution ductwork system. The MCR HVAC system is capable of operating in the normal, emergency pressurization, emergency isolation, and emergency smoke purge operation modes. The MRC

HVAC system, with the exception of the toilet/kitchen exhaust and smoke purge subsystems, is classified as safety-related and Seismic Category I.

9.4.1.2 Summary of Application

DCD Tier 1: US-APWR DCD Tier 1 addresses the MCR HVAC system and MCR emergency filtration system in Section 2.7.5.1. The two main constituents are the design bases of the MCR HVAC system covered in the text and tables of Section 2.7.5.1.1 and the ITAAC of Section 2.7.5.1.2.

DCD Tier 2: US-APWR DCD Tier 2 Section 9.4.1 provides the MRC HVAC design. The safety-related MCR HVAC system supports the MCR, which is located in the RB. The NRC SE of the MCR HVAC system is provided in Section 9.4.1.4 of this SER.

Design Basis for the MCR HVAC System

The MCR HVAC System is designed to meet the following safety design bases:

- Exclude entry of airborne radioactivity into the Control Room Envelope (CRE) and remove radioactive material from the CRE environment such that radiation dose to MCR personnel is within the GDC 19 (10 CFR 50, Appendix A).

- Support and maintain CRE habitability and permit personnel occupancy and proper functioning of instrumentation during normal and DBAs, assuming a single active failure.

- Withstand the effects of adverse environmental conditions.

- Withstand the effects of tornadoes and tornado missiles.

- Withstand the effects of seismic events. The MCR HVAC system equipment and the associated ductwork are designed to Seismic Category I requirements.

- Provide the MCR personnel protection by detecting and preventing the introduction of smoke into the CRE by automatically aligning the system to the emergency isolation mode (Chapter 6, Section 6.4).

- Automatically switch from normal operating mode to emergency pressurization mode upon the MCR isolation signal (Chapter 7).

- Automatically switch from normal operating mode to the emergency isolation mode upon the detection of smoke in the outside air intakes (Chapter 6, Section 6.4).

The emergency filtration units are designed and constructed in accordance with ASME Standard N509 (Reference 9.4.8-1), AG-1 (Reference 9.4.8-2) and with the recommendations of RG 1.52 (Reference 9.4.8-3).

Proper MCR personnel protection against toxic gases is described in Chapter 6, Section 6.4.

ITAAC: DCD Tier 1, Section 2.7.5.1.2 provides the ITAAC associated with DCD Tier 2, Section 9.4.1.e.

TS: TS in US-APWR DCD Chapter 16 extensively address the MCR HVAC system and MCR emergency filtration system in Sections 3.7.10 and B 3.7.10. MCR radiation and isolation from radioactivity is covered in Section B 3.3.2. Section 5.5.11 applies to the ventilation filter testing program and Section 5.5.20 applies to the Control Room Habitability Program.

9.4.1.3 Regulatory Basis

The staff reviewed DCD Tier 1 Section 2.7.5.1 and Tier 2 Section 9.4.1, "Main Control Room HVAC System," in accordance with SRP Section 9.4.1, "Control Room Area Ventilation System."

The applicant's CRAVS is acceptable if it meets the following relevant requirements:

- GDC 2, "Design Bases for Protection Against Natural Phenomena," as related to the system and its components important to safety being capable of withstanding the effects of natural phenomena such as earthquakes, tornados, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions.

- GDC 4, "Environmental and Dynamic Effects Design Bases," as it relates to the CRAVS being appropriately protected against dynamic effects and being designed to accommodate the effects of, and to be compatible with, the environmental conditions of normal operation, maintenance, testing, and postulated accidents. The GDC 4 evaluation includes the adequacy of environmental support for safety-related SSCs within areas served by the CRAVS.

- GDC 5, "Sharing of Structures, Systems, and Components," as it relates to shared SSCs among nuclear power units.

- GDC 19, "Control Room," A control room shall be provided from which actions can be taken to operate the nuclear power unit safely under normal conditions and to maintain it in a safe condition under accident conditions, including LOCAs. Adequate radiation protection shall be provided to permit access and occupancy of the control room under accident conditions without personnel receiving radiation exposures in excess of five rem whole body, or its equivalent to any part of the body, for the duration of the accident.

- GDC 60, "Control of Release of Radioactive Materials to the Environment," as it relates to system capability to suitably control release of gaseous radioactive effluents to the environment.

- 10 CFR 50.63, as it relates to necessary support systems providing sufficient capacity and capability to ensure the capability for coping with an SBO event. An analysis to determine capability for withstanding (if an acceptable AAC source is provided) or coping with an SBO event is required. The analysis should address, as appropriate, the potential failures of equipment/systems during the event (e.g., loss or degraded operability of heating, ventilating, and air conditioning systems, including the CRAVS, as appropriate), the expected environmental conditions associated with the event, the operability and reliability of equipment necessary to cope with the event under the expected environmental conditions, and the habitability of plant areas requiring operator access during the event and associated recovery period.

- 10 CFR 52.47(b)(1), which requires that a DC 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 facility 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.

9.4.1.4 Technical Evaluation

Summary of RAI Exchange

As part of the staff evaluation during the DCD review process, 32 RAIs were initially prepared. In its response letter (ML082810407) dated, October 3, 2008, titled “MHI Responses to US-APWR DCD RAI 849-63, Revision 0,” the applicant provided responses to the RAIs. Follow-up RAIs were prepared regarding eight of the responses for RAI 327-2401 that the applicant provided in a letter dated June 19, 2009 (ML091751095). The staff also generated three follow-up questions in RAI 475-3780, Revision 1. The applicant responded to RAI 475-3780 dated November 20, 2009 (ML093290031).

Four other RAIs were required during the review process: RAI 582-4456 (ML102010040); RAI 689-4976 (ML110770284); RAI 642-4770 (ML103120402); and RAI 6063.

In addition, the staff requested that the applicant justify the use of a newer (i.e. non-endorsed staff) version of the ASME AG-1 code in RAI 442-3378. The applicant responded to RAI 442-3378 on September 18, 2009 (ML092650173). The staff issued follow-up RAI 484-3850, Revision 1, to which the applicant responded on December 9, 2009 (ML093480146).

General Design Criterion 2

The staff reviewed the MCR HVAC system to ensure that the relevant requirements of GDC 2 are met. The staff reviewed the MCR HVAC system for the US-APWR in accordance with Section 9.4.1 of the SRP. The MCR HVAC system was reviewed to ensure that the system is capable of withstanding the effects of natural phenomena by meeting the guidelines of RG 1.29, “Seismic Design Classification,” Position C.1 for safety-related portions of the system and Position C.2 for non safety-related portions of the system.

In RAI 63, Question 09.04.01-22, the staff requested additional information regarding the ductwork downstream (i.e. outside the CRE) from the outermost safety-related Seismic Category I isolation dampers associated with the toilet/kitchen exhaust and smoke purge fans to the final destination of these two exhaust flows. In particular, the staff requested additional information regarding how the design of this ductwork satisfies the Regulatory Positions C.1, C.2 and C.3 of RG 1.29. The staff requested additional information with respect to: (1) the ultimate destination of the discharge flow from the toilet/kitchen exhaust and smoke purge fans; (2) the purpose(s) of the back draft dampers; and (3) the reason for not addressing these dampers in Table 3.2-2. The staff requested that the applicant amend (as applicable) the DCD to reflect the additional information provided. The applicant responded in a letter dated October 03, 2008 (ML082810407), with a proposed mark-up of Figures 9.4-1, 6.4-2, 6.4-3 and 6.4-4 to indicate the classification for the MCR HVAC system, including MCR toilet/kitchen exhaust and MCR smoke purge fan. The applicant clarified the DCD and provided additional detail to clearly designate the system class boundary. The staff found this acceptable. The staff verified that Revision 2 of the US-APWR DCD included the changes in DCD Section 9.4.1.2, Table 3.2-2, and Figure 9.4.1-1, 6.4-2, 6.4-3 and 6.4-4.

However, the staff found that the figure changes were not clear with respect to non safety-related instrumentation Seismic Category II/I boundaries and that the third line item of Table 3.2-2 (Sheet 46 of 47) contained ambiguous wording in an attempt to capture the back draft dampers for the two MCR kitchen/toilet exhaust fans. These two residual issues were resolved by follow-up RAI 582-4456, Question 09.04-01-16, against RAI 849-63, Question 09.04.01-19. The staff verified that Revision 3 of the DCD contained the requisite changes to Table 3.2-2 specified in RAI 582-4456, Question 09.04-01-16. Based on this revision the staff **closed RAI 849-63, Question 09.04.01-22.**

In RAI 849-63, Question 09.04.01-19, the staff noted that relevant DCD P&IDs (e.g. Figures 9.4.1-1, 6.4-2) fail to differentiate the essential portions of the CRAVS from nonessential portions of the system.

The staff noted this to be in conflict with the review guidance of SRP 9.4.1 Section III "Review Procedures," and the staff requested that the applicant provide additional information and amend the DCD, as necessary. After a number of RAIs were exchanged, the applicant responded in a letter dated July 16, 2010 (ML102010040), with a revision to DCD figures 9.4.1-1, 6.4-2, 6.4-3 and 6.4-4 that included clarifying notes to address the staff's concern regarding non safety-related instrumentation breaching the CRE boundary. The applicant amended DCD Table 3.2-2 line items for ductwork and dampers of the MCR HVAC system with descriptions that clearly identify which ductwork and what dampers are Seismic II (i.e. not Seismic I) and Equipment Class 5 (i.e. not 3). The staff reviewed the applicant's response in conjunction with DCD Subsection 3.2.1.1.2. Based on this review, the staff concluded that the DCD satisfies the guidance of SRP 9.4.1 Section III, "Review Procedures" 2.A and 2.B.

The staff's review of Revision 3 of the DCD found that the applicant had not incorporated the changes to Figures 9.4.1-1, 6.4-2, 6.4-3 and 6.4-4. However, the change of approach included in Revision 3 of the DCD as reflected in Figure 9.4.1-1, reflects installing the duct heater and humidifier and related ductwork within the CRE boundary. Thus the requested changes to Figures 9.4.1-1, 6.4-2, 6.4-3 and 6.4-4 proved not to be necessary. The staff notes that Table 3.2-2 was revised consistently with the applicant's proposed amendment, and that the humidifier and duct heater are correctly listed as Seismic Category II (Sheet 44 of 56 of this Table). Based on these DCD revisions which clarified the classifications in conformance with the SRP, the staff **closed RAI 849-63, Question 09.04.01-19, and RAI 582-4456, Question 09.04.01-16.**

General Design Criterion 4

The staff reviewed the MCR HVAC system to ensure that the relevant requirements of GDC 4 are met. The MCR HVAC system was reviewed to ensure that the system meets requirements by appropriately addressing adverse environmental conditions and dynamic effects in the design of the system to ensure its capability for maintaining environmental conditions in the control room within the design limits of equipment important to safety located therein for normal, transient, or accident conditions.

In RAI 849-63, Question No. 09.04.01-5, the staff noted that in its review of DCD Section 9.4.1 it could not find GDC 4 "Environmental and dynamic effects design bases," of Appendix A to 10 CFR 50 addressed in any detail. The staff requested that the applicant provide additional information regarding how the design of the MCR HVAC system, as described in Section 9.4.1, complies with GDC 4.

After several RAIs were exchanged, the applicant in a letter dated June 19, 2009 (ML091751095), provided additional technical detail. The applicant amended DCD Section 9.4.1.3 to clarify that MCR HVAC equipment was protected and against piping failures and that the basis for protection is discussed in Section 3.6.2 of the DCD. The staff found the applicant's response to RAI 849-63, Question 09.04.01-5, acceptable since the DCD now addresses the GDC 4 requirement pertaining to environmental and dynamic effects. Based on this change, the staff **closed RAI 849-63, Question 09.04.01-5.**

The staff evaluated the applicant's DCD Section 9.4.1 for the MCR HVAC System equipment design and operation and for the control room habitability environment, against prescribed SRP 9.4.1 review guidance. In RAI 849-63, Question No. 09.04.01-9, the staff requested that the applicant provide additional details for the calculations supporting the normal and abnormal condition minimum - maximum temperatures and calculations supporting the normal and abnormal condition minimum - maximum relative humidity percentages to ensure adequate conditions are maintained to comply with GDC 4. The applicant responded in a letter dated October 03, 2008 (ML082810407), that DCD Section 9.4.1, Table 9.4-1 shows the design temperature and relative humidity of each room. The applicant stated that these values are not determined from calculation. This design value of the MCR is based on the Utility Requirements Document (URD). The staff confirmed that the values for minimum and maximum temperatures of 73 °F and 78 °F for the MCR contained in DCD Table 9.4-1 agrees with the criteria for "occupied areas: light work" contained in Section 8.2.1.1 of EPRI URD (DCD Reference 9.2.11-7). However, the staff found the applicant's response to RAI 849-63, Question 09.04.01-9 to be incomplete. The staff observed that Table 9.4.1-1 contains cooling coil capacities for the MCR AHUs. The staff noted that these capacities would have been derived through model calculations where the inputs (i.e. design temperature values) of Table 9.4-1 were used as desired outcomes. The staff needed to review these model calculations to establish the adequacy of the values in Table 9.4-1. Based on this, the staff issued RAI 327-2401, Question 09.04.01-3, to obtain the needed information.

The applicant responded in a letter dated June 19, 2009 (ML091751095), that RAI 849-63, Question 09.04.01-14 (ML082810407), provides the calculations used in sizing the design base capacity of the AHUs. The design base heat loads used in these calculations bound the normal plant condition and the abnormal plant condition such as a DBA. The maximum relative humidity within the MCR is controlled by these AHUs. The minimum relative humidity is controlled by the humidifier that is designated as nonsafety-related and Seismic Category II.

The applicant proposed to revise the first paragraph of DCD Section 9.4.1.2 as follows: "*Non-safety related electric in-duct heaters and a humidifier that are designed as Seismic Category II are located in the duct branches leading to the MCR*." In addition, the applicant proposed to revise Table 3.2-2 (under Item 36, Sheets 43 and 44) "Classification of Mechanical and Fluid Systems, Components, and Equipment" to add the listing of the humidifier.

While the staff verified that Revision 2 of the US-APWR DCD contained the applicant's changes for the humidifier in DCD Section 9.4.1.2 and Table 3.2-2, the staff found the applicant's response to RAI 327-2401, Question 09.04.01-3 incomplete. The staff questioned the applicant as to the basis for establishing the humidifier for the MCR HVAC system as nonsafety-related as opposed to safety-related since the US-APWR DCD Table 9.4-1 specifies for normal conditions a MCR relative humidity range of 25-60 percent and does not list a Residual Heat (RH) for abnormal conditions. The staff observed that a humidifier is not listed in Environmental Qualification (EQ) Table 3D-2 and that DCD Chapter 3 does not give a humidity range in its definition of a mild environment.

Based on this, the staff issued follow-up RAI 475-3780, Question 09.04.01-13. The applicant responded on November 20, 2009 (ML093290031), by indicating that safety-related electrical equipment and instrumentation in the MCR are qualified for maximum 95 percent (non-condensing).

The applicant noted that since the humidifier is located in a duct branch, nonsafety-related equipment is not a risk-significant component, and DCD Table 9.4.1-1, "Equipment Design Data," will not be required to be revised to include the humidifier. The applicant proposed to further amend the DCD with a two part change:

1. Figure 9.4.1-1, "MCR HVAC System Flow Diagram," will be revised to show the humidifier and the associated humidity instrument in DCD Revision 2.
2. DCD Subsection 9.4.1.2.1, will be revised with the addition of a bullet that will read "The non-safety in-duct humidifier is controlled by a humidity instrument located in the Main Control Room." The staff verified that DCD Revision 3 included this change.

The staff verified that the other three changes to Section 9.4.1.2, Table 3.2-2 and Figure 9.4.1-1 were included in Revision 2 of the DCD. After evaluating the applicant's response to RAI 475-3780, Question 09.04.01-13, the staff concluded that the applicant had provided sufficient detail in the FSAR for the non safety-related in-duct heaters but had failed to provide sufficient justification for the existence of nonsafety-related humidifiers and associated controls. Based on this, the staff holds this as **Open Item 6063, Question 09.04.01-31-- RAI 849-63, Question RAI 09.04.01-9; MHI RAI 327-2401, Question 09.04.01-3; RAI 475-3780, Question 09.04.01-13; RAI 582-4456, Question 09.04.01-19 and RAI 689-4976, Question 09.04.01-27.** The staff issued **RAI 6063, Question 09.04.01-31, Open Item 09.04.01-31** requesting additional information regarding nonsafety-related humidifiers.

The staff noted in RAI 849-63, Question 09.04.01-14, that SRP 9.4.1, Section IV.1.C suggests that the staff review calculations in support of its conclusions that the equipment capacities are of adequate design. For the equipment listed in Table 9.4.1-1, the staff requested additional details regarding the calculations used to establish the equipment design data including: fan unit airflow, cooling coil, and heating coil capacities.

The applicant responded in a letter dated June 19, 2009 (ML091751095), with more detailed information. The applicant proposed to verify the heat loads and cooling coil capacity using ITAAC and TS surveillances. These regulatory tools are acceptable ways to demonstrate the capability of safety systems and the staff finds the applicant's approach acceptable. The applicant responded with specific values for SR 3.7.10.5 for a plant located at the worst case condition site. The staff found that using this value as the threshold acceptance value in SR

3.7.10.5 for all US-APWR plants is conservative with respect to the issue of adequate excess MCR cooling margin.

From May 24 - 28, 2010, the staff performed an audit (ML110800203) of Mitsubishi Nuclear Energy Systems (MNES) Calculation N0-EE23101 “US-APWR Standard Design - Main Control Room HVAC System (MCRVS) Calculations.” During the audit, the staff noted to the applicant that the system operational configuration used to determine the most limiting design heat load was not the configuration that yields the highest heat load for the system. The applicant amended Calculation N0-EE23101 to correct the error. The staff issued RAI 642-4770, Question 09.04.01-24, to track the issue.

The applicant responded on November 05, 2010 (ML103120402), by identifying the heat loads associated with: (1) the normal operating mode, (2) the emergency pressurization mode and (3) the emergency isolation mode. The applicant adequately detailed why the heat load during the normal operating mode bounds the heat loads of both the emergency isolation mode and the pressurization mode. Based on this, the applicant concluded that the total combined cooling coil capacity of the four MCR AHUs, DCD Table 9.4.1-1, did not need to be changed (i.e. remains at 341,000 Btu/hr). The applicant subsequently submitted Technical Report “Safety-Related Air Conditioning, Heating, Cooling, and Ventilation Systems Calculations,” (MUAP-10020) summarizing the safety-related HVAC system calculations and amended the DCD to include this as a reference in Subsection 9.4.8. The staff notes that Revision 3 DCD Subsection 9.4.8 references the November 2010, version of Technical Report MUAP-10020 instead of the most recent revision dated March 2011. The staff notes that this DCD deficiency was addressed with follow-up **RAI 5999, Question 09.04.05-21**. Based on this fact, the staff holds the **RAI Series RAI 849-63, Question 09.04.01-14; RAI 327-2401, Question 09.04.01-5; RAI 642-4770, Question 09.04.01-24; and RAI 5999, Question 09.04.05-21 as Confirmatory Item 09.04.05-21**.

In RAI 849-63, Question 09.04.01-25, the staff noted that DCD Table 9.4.1-1 “Equipment Design Data” indicates that the design supply air flow rates to the CRE from two MCR AHUs equals 20,000 cfm. This same table indicates that operation of one of the MCR Toilet/Kitchen Exhaust Fans will remove 1800 cfm from the CRE. The staff found that beyond this information the COL applicant has no supply and exhaust flow information available in the DCD to flow balance the HVAC system to maintain normal area temperatures. The staff requested that the applicant amend DCD Section 9.4.1 to include the design basis flow rates for all four modes of system operation to the particular areas of the CRE.

The applicant responded in a letter dated October 3, 2008 (ML082810407), with a proposed revision to the DCD to include the design basis flow rates for all four modes of system operation. These changes were adequate to resolve the inconsistencies and assure that the testing will establish an acceptable system. The staff verified that Revision 3 of the US-APWR DCD contained the changes identified above. Based on the above, the staff **closed RAI 849-63, Question 09.04.01-25.**

The staff evaluated the applicant’s DCD Section 9.4.1 conformance with the MCR HVAC System equipment design guidance prescribed in SRP 9.4.1. In RAI 849-63, Question 09.04.01-8, the staff found that DCD Section 9.4.1 “Main Control Room Heating, Ventilation and Air Conditioning System,” did not contain a FMEA. The staff requested that the applicant provide detailed information regarding the failure modes and effects analysis in DCD Section 9.4.1. In a letter dated October 03, 2008 (ML082810407), the applicant indicated that it would add a FMEA for the MCR HVAC system to the DCD. The staff verified that Revision 3 of the US-APWR DCD included the FMEA for the MCR in Table 9.4.1-2.

However, the staff's review of Table 9.4.1-2 found the FMEA did not address a failure mode of concern. In follow-up RAI 582-4456, Question 09.04.01-18, the staff noted that the HVAC AHUs are located directly above the MCR. The staff asked what design features would prevent the failure of an essential chilled water cooling coil leak inside the HVAC AHUs above from adversely impacting the MCR below.

The applicant responded in a letter dated July 16, 2010 (ML102010040), with an answer that required further questioning in RAI No. 689-4976, Question No. 09.04.01-25. In particular, the staff requested that the applicant (a) explain how the leakage from a potential failure of a cooling coil would be directed to the drain system, (b) explain how the bypass of the drain system is precluded and (c) explain how the drain system will be sized, tested and maintained to ensure that it can accommodate the full flow from a cooling coil leak throughout the life of the plant.

The applicant responded in a letter dated March 15, 2011 (ML110770284), that DCD Table 3.2-2, “Classification of Mechanical and Fluid Systems, Components, and Equipment,” the MCR AHU cooling coils are safety-related, Equipment Class 3, Seismic Category I components. In addition, as identified in DCD Table 3.6-1, “High and Moderate Energy Fluid Systems,” the Chilled Water System is a moderate energy system, which is defined in DCD Section 3.6.1.1.

10 CFR 50, Appendix A, GDC 4 requires protection of safety-related SSCs from the dynamic effects of equipment failures and external events. The dynamic effects of equipment failures, including the effects of discharging fluids, are addressed in DCD Section 3.4, Water Level (Flood) Design, and Section 3.6, “Protection Against Dynamic Effects Associated with Postulated Rupture of Piping.”

DCD Section 3.4 evaluates the effect of flooding from external and internal sources regarding safety related SSCs. The internal water source events are seismic events, pipe breaks and cracks, firefighting operations, and pump mechanical seal failures. DCD Section 3.4.1.3 identifies that only equipment or pipe not classified as Seismic Category I is considered to contribute to flooding due to a seismic event and that, for flooding events caused by the postulated failures of piping, pipe failures are defined in DCD Section 3.6.

The staff found that the applicant's response to RAI 689-4976, Question 09.04.01-25, provided useful information as to why a leak from the cooling coils is unlikely to occur. However, the applicant failed to provide sufficient information regarding the design of the AHU cooling coils for the staff to conclude that such a leak, should it occur, would not present a coincidental common mode failure to the I&C of the MCR via the common HVAC duct lines (i.e. supply and return). Based on this, the staff lists the RAI series as **Open Item -- RAI 849-63, Question 09.04.01-8; RAI 582-4456, Question 09.04.01-18 and RAI 689-4976, Question 09.04.01-25.** The staff issued **RAI 6063, Question 09.04.01-32, Open Item 09.04.01-32** requesting additional information regarding the design of the MCR air handling unit cooling coils.

General Design Criterion 5

The staff reviewed the MCR HVAC system to ensure that the relevant requirements of GDC 5 are met. Since the design application is for a single unit plant, GDC 5 does not apply to this system.

General Design Criterion 19

The staff reviewed the MCR HVAC system to ensure that the relevant requirements of GDC 19 are met. The MCR HVAC system was reviewed to ensure that the system meets requirements with respect to the capability of the system to maintain a suitable environment in the control room for occupancy during normal and accident conditions by meeting the guidelines of RG 1.78.

In RAI 849-63, Question 09.04.01-32, the staff requested that the applicant provide additional information regarding the location of the ESF Filter train fresh air intakes with respect to known on-site fresh air contaminants such as diesel fumes, chemical storage tanks etc. Following a series of RAI exchanges, the applicant revised DCD Section 9.4.8 to cite "The International Mechanical Code" (Section 401.5.1). The staff verified that Revision 3 of the DCD listed this reference. The applicant also amended DCD Subsection 9.4.3.1 to describe the Emergency GTGs and their impact on the ventilation systems. The staff found the applicant's response of January 29, 2010, acceptable but noted that the applicant had not completed all the necessary revisions in Revision 2 of the DCD. The staff notes that the amended response (ML100330616) to RAI No. 327-2401, Question No. 09.04.01-9, was issued after Revision 2 of the DCD was issued. The applicant clarified in the DCD, the potential sources for air contamination and the distances of key exhaust points from the GTGs to the CRE fresh air intakes. The applicant clarified that the MCR HVAC system is compliant with RG 1.52, which addresses the effects of adverse environmental contaminants. The applicant also clarified that COL Information Item 6.4(1) addresses RG 1.78 and the design and location of air intakes for the MCR HVAC System. The staff verified that Revision 3 of the DCD contained all requisite changes and therefore, the staff **closed RAI 849-63, Question 09.04.01-32, and follow-up RAI 327-2401, Question 09.04.01-9.**

In RAI 849-63, Question 09.04.01-28, the staff requested the applicant to clarify the DCD's information concerning the MCR fresh air intake radiation monitors. The staff found that DCD Figures 9.4.1-1, 6.4-2, 6.4-3 and 6.4-4 display two radiation monitors in a location that appears to be sensing radiation from both outside-fresh-air intake lines simultaneously. The staff asked if the line (i.e. in these figures) that the radiation monitors connect to, represents a cross-connect between the two ESF filter trains.

In summary, the staff requested that the applicant provide additional information regarding this instrumentation configuration with respect to:

1) the number of monitors shown (i.e. two) on the listed figures versus the six monitors described in DCD Section 7.3.1.5.7;

2) the implications of safety-related divisional separation for these SR monitors since both shown monitors appear to be tied to both divisional trains of the ESF filter trains; and

3) the physical location (i.e. distance from) of the radiation monitors with respect to the missile shields (i.e., air inlet of Figure 6.4-5) to the ESF filter trains and to the

redundant safety-related leak-tight dampers VRS-MOD-101A, VRS-MOD-102A, VRS-MOD-101B and VRS-MOD-102B.

The applicant responded to RAI 849-63, Question 09.04.01-28, in a letter dated October 03, 2008 (ML082810407), with clarification regarding the monitors. The applicant proposed to revise DCD Figures 6.4-2, 6.4-3, 6.4-4 (DCD Section 6.4), and 9.4.1-1 (DCD Section 9.4.1) by adding the exact number of monitors and a new clarifying note to each of the listed figures. The staff found the applicant's proposed changes acceptable since these changes add sufficient clarity to the DCD as to the number of monitors located at the fresh air intakes and as to how the sensing lines to the monitors maintain divisional separation. The applicant also provided an explanation of the location of the intake radiation monitors with respect to the missile shields that assure instrument protection. Based on this explanation and the revision of the DCD, the staff found the applicant's response to RAI 9.4.1-28 acceptable. The staff verified that Revision 3 of the US-APWR DCD contained the changes in DCD Figures 6.4-2, 6.4-3, 6.4-4 and 9.4.1-1. Based on this, the staff **closed RAI 849-63, Question 09.04.01-28.**

General Design Criterion 60

The staff reviewed the MCR HVAC system to ensure that the relevant requirements of GDC 60 are met. The MCR HVAC system was reviewed to ensure that the system is capable of suitably controlling release of gaseous radioactive effluents to the environment by meeting the guidelines of RG 1.52 and RG 1.140 as related to design, inspection, testing, and maintenance criteria for post–accident and normal atmosphere cleanup systems, ventilation exhaust systems, air filtration, and adsorption units.

The staff noted that the MCR HVAC System contains ESF filter trains governed by the regulatory guidance of Subsection C.3 "Design Criteria," of RG 1.52. The staff requested that the applicant amend DCD Subsection 9.4.1 in RAI 582-4456, to document how the ESF filter trains of the MCR HVAC system satisfy the "System Design Criteria" of Subsection C.3 "Design Criteria" of RG 1.52. The applicant responded with a letter dated July 16, 2010 (ML102010040), that DCD Section 6.4, Table 6.4-2 presents design feature and fission product removal capabilities of the MCR emergency filtration system.

In RAI 689-4976, Question 09.04.01-26, the staff submitted a more focused multi part question about the design of the components of the MCR emergency filtration system based on the guidance of RG 1.52 and SRP 6.5.1. The staff notes that Revision 1 DCD contained COL Information Item 6.4(4) "*The COL Applicant is responsible to determine the charcoal adsorber weight, type and distribution.*" The staff also notes that this COL item had been deleted from Revision 2 of the DCD and that Revision 2 contained insufficient information to determine if RG 1.52 was met with respect to carbon filters of the MCR emergency filtration units. The multi part RAI 689-4976, Question 09.04.01-26, requested further information about: (1) the design average atmosphere residence time based on charcoal bed depth and adsorber weight; (2) the maximum iodine loading of the charcoal beds of the MCR emergency filtration units based on adsorber weight; (3) the design percentage limitations (≤ 5 percent of the total carbon) placed on the impregnant carbon; (4) what design features of the adsorbent beds will prevent the bed temperatures from approaching 300 ºF thereby permitting iodine desorption from taking place. In particular the staff asked about maximum component temperatures: (a) in the adsorber section with normal flow conditions and (b) with the unit shut down and the charcoal adsorbent unit isolated (i.e. post LOCA condition); (5) contingency measures included in the plant design to mitigate the conditions of a failed fan post-LOCA resulting in a charcoal temperature rise from the radioactivity-induced heat in the adsorbent. This value should be below the 626 °F (330 ºC

– Reference AG-1-2003, page 435) charcoal ignition temperature; (6) the absence of demisters in the filter train design; and (7) whether the HEPA filters have sufficient design margin to accommodate fission product loading without restricting flow rate.

The applicant responded in a letter dated March 15, 2011 (ML110770284), with incomplete answers for four parts of RAI 689-4976, Question 09.04.01-26. Based on this, the staff lists these related issues as **Open Item -- RAI 849-63, Question 09.04.01-6; RAI 582-4456, Question 09.04.01-23; RAI 689-4976, Question 09.04.01-26.** The staff issued **RAI 6063, Question 09.04.01-29; Open Item Question 09.04.01-29** requesting additional information regarding parts (4), (5), (6) and (7). As of the writing of this SER, the staff was in discussion with the applicant regarding what clarifying information was needed to allow the staff to make a regulatory finding.

The staff noted that there was no reference to the replacement of filters used during plant/system construction in DCD Section 9.4.1 consistent with Position C 5.2 of RG 1.52. In RAI 849-63, Question 09.04.01-31, the staff requested that the applicant amend DCD Section 9.4.1 to address this position. The applicant responded in a letter dated October 03, 2008 (ML082810407), with a revision of DCD Section 9.4.1.4 to address filter replacement. Based on this change as captured in Revision 3 of the US-APWR DCD, the staff found the applicant's response acceptable since the DCD is now consistent with RG 1.52 guidance. The staff **closed RAI 849-63, Question 09.04.01-31.**

The standards employed in the design of the US-APWR were the subject of RAI 442-3378, Question 09.04.01-10. Specifically the staff questioned the use of a more recent version of ASME AG-1 than had been endorsed by the staff. Revision 3 of RG 1.52 endorses ASME AG-1-1997 while the applicant's DCD referenced AG-1-2003 and AG-1a-2000. The applicant responded to RAI 442-3378, Question 09.04.01-10, with two RAI responses dated September 18, 2009, and December 09, 2009, (ML092650173 and ML093480146) that made a comparison of the endorsed version versus the newer version. The results of the review were provided in a table. The applicant concluded that the use of the 2003, edition of the Code, rather than the 1997, edition referenced in the NRC guidance documents, is justified. The staff conducted an independent side-by-side comparison of the two AG-1 Codes to confirm that the use of ASME AG-1-2003 edition is an acceptable alternative to ASME AG-1-1997 for the MCR HVAC system design and testing. For the substantive areas of difference the applicant provided a comprehensive technical justification (as applicable) for the use of AG-1-2003 and AG-1a-2000, in lieu of AG-1-1997, in the design of the US-APWR DCD ventilation subsections. Based on this review, the staff concluded that the applicant had provided sufficient justification to demonstrate that the proposed alternatives to the SRP acceptance criteria provide acceptable methods of compliance with the NRC regulations. Based on this finding, the staff **closed both RAI 442-3378, Question 9.4.1-10, and RAI 484-3850, Question 09.04.01-15**.

10 CFR 50.48 Fire Protection

The regulatory requirements in 10 CFR 50.48 are partially addressed by the staff in this section of the SER and further addressed in SER Section 9.5.1, "Fire Protection Program."

The staff evaluated the applicant's DCD Section 9.4.1 conformance with the MCR HVAC system handling of smoke issues that are of concern to the control room habitability environment with SRP 9.4.1. RAI 849-63, Questions 09.04.01-13, 09.04.01-26 and 09.04.01-30 were written to address the SRP guidance. RAI 849-63, Question 09.04.01-13 addressed a staff concern about there not being a redundant fan for the smoke fan. RAI 849-63, Question

09.04.01-26 addressed a staff concern about smoke detectors and alarms in the MCR HVAC system. RAI 849-63, Question 09.04.01-30 addressed a concern regarding fire damper operation at all openings to the CRE.

The staff noted in RAI 849-63, Question 09.04.01-13, that DCD Section 9.4.1.2 reads that the MCR HVAC system has two redundant 100 percent filtration units, four 50 percent capacity AHUs, two redundant toilet/kitchen exhaust fan units, and one 100 percent smoke purge fan unit. Figure 9.4.1-1 shows redundant trains for the toilet/kitchen exhaust fan units. The smoke purge fan does not have a redundant fan unit shown. The staff requested that the applicant provide additional information and clarify why only one 100 percent smoke purge fan unit is adequate.

The applicant's response dated October 03, 2008 (ML082810407) indicated that the smoke purge mode of operation is normally used, after a fire has been extinguished, for quick removal of smoke from the area. DCD Section 9.5.1 and Appendix 9A, "Fire Hazard Analysis," provides further details of this operation. The applicant went on to note that the smoke purge portion of the MCR HVAC system outside the CRE and downstream of the safety related isolation damper at the wall of the CRE does not serve any safety-related function and has no safety design bases. Therefore, there is no requirement to provide redundancy for the smoke purge fan. The smoke purge fan is sized to provide 10 air changes per hour so that no more than 6 minutes are required to gain entry back into the MCR after the fire has been extinguished.

Based upon a review of the applicant's response, the staff agreed with the applicant that a backup or redundant fan is not required for the smoke purge mode of operation. The staff based this conclusion on the following findings: (1) the fan is normally secured during normal plant operations and (2) the fan serves no safety-related function. Based on these findings, the staff found the applicant's response acceptable. The staff **closed RAI 849-63, Question 09.04.01-13.**

In RAI 849-63, Question 09.04.01-26, the staff noted that in DCD Section 9.4.1.2.3, "Smoke Purge Operation mode" describes smoke detection and annunciation. However, there are no area smoke detectors displayed within the CRE in any of the figures related to DCD Sections 9.4.1 and 6.4 "Habitability Systems," and there is no description in Section 6.4.

The staff requested that the applicant include the details of these MCRE area smoke detectors and MCR alarms in the relevant subsections of the DCD. The applicant responded in a letter dated October 03, 2008 (ML082810407), with a mark-up of DCD subsection 9.4.1.5, "Instrumentation Requirements," that included a reference to the fire requirements. The staff found these changes acceptable in that they provided the necessary detail on smoke detection and alarms. The staff reviewed Revision 3 of the US-APWR DCD, and verified that the applicant did amend the last paragraph of DCD Subsection 9.4.1.5 consistent with the above. The staff **closed RAI 849-63, Question 09.04.01-26.**

In RAI 849-63, Question No. 09.04.01-30, the staff requested that the applicant provide additional information regarding what generic HVAC system attributes contained in the passage from DCD Subsection 9.5.1.2.7 "Building Ventilation," are applicable to the operation of the MCR HVAC system.

The applicant responded in a letter dated October 03, 2008 (ML082810407), with additional design detail. The staff found the applicant's RAI response as fundamentally acceptable but incomplete. With the supplemental information provided, the applicant adequately filled in the gaps in information specific to fire protection system operation and its impact on the MCR HVAC system. However, the applicant did not propose to add any of this information to the DCD in either Subsections 9.4.1 or 9.5.1. To address this omission, the staff issued follow-up RAI 582-4456, Question 09.04.01-21, and requested that the applicant amend DCD Subsection 9.4.1 with the fire protection attributes described in the response to Question 09.04.01-30**.** The applicant responded in a letter dated July 16, 2010 (ML102010040), with a DCD mark-up revising the last paragraph of DCD Subsection 9.4.1.2 to include the necessary attributes.

The staff found the applicant's resolution to the issue of concern identified in RAI 582-4456, Question 09.04.01-21, adequate in that it clarified the design basis overlap between the safety-related MCR HVAC system and the fire protection system. The staff verified that Revision 3 of the DCD contained the requisite changes and **closed RAI 849-63, Question 09.04.01-30, and RAI 582-4456, Question 09.04.01-21.**

10 CFR 50.63 Loss of all alternating current power

The regulatory requirements in 10 CFR 50.63 are partially addressed by the staff in this section of the SER and further addressed in SER Section 8.4, "Station Blackout."

The staff evaluated the applicant's DCD Section 9.4.1 for the ability of the MCR HVAC System to cope with a SBO event. The staff noted in RAI 849-63, Question 09.04.01-11 that the review guidance of SRP 9.4.1 Section III.1 requires a review of the DCD for normal and emergency operations, and the ambient temperature limits for the areas serviced. In particular, DCD Section 9.4.1.1.2 discusses SBO for the electrical equipment areas in the MCR HVAC system. The staff inquired as to whether SBO should also be listed in Table 9.4-1 "Area Design Temperature and Relative Humidity" as an abnormal condition with minimum and maximum temperatures for the areas serviced by the MCR HVAC system.

The applicant responded in a letter dated October 03, 2008 (ML082810407), with an explanation describing the SBO event. The staff found the applicant's response was adequate in that the applicant explains that the SBO event impact on the MCR temperature is a short term one hour transient event. Being a transient event, listing the SBO event in Table 9.4-1 as an expected stable temperature is not appropriate. In addition, the applicant's response to RAI 849-63, Question No. 09.04.01-12 (below), provides sufficient detail about this transient one hour event for the staff to make a regulatory finding. Based on the information presented, the staff found the applicant's RAI response acceptable and **closed RAI 849-63, Question 09.04.01-11.**

In RAI 849-63, Question 09.04.01-12, the staff requested that the applicant provide additional details including calculations that establish the one hour delay basis with associated assumptions and margins. The applicant's response in a letter dated October 03, 2008 (ML082810407), failed to provide sufficient detail. Numerous RAIs were exchanged and technical information was reviewed. The applicant's responses described the calculation procedure and the design basis. Refer to the applicant document RAI 327-2401, Question 09.04.01-4 (ML091751095), for this information. In its response dated June 19, 2009, the applicant noted that "*All MCR instrumentation, controls and alarms are qualified to operate at SBO event.*" The applicant did provide reasonable assurance that temperatures within the MCR Class 1E I&C panels and electrical panels located in the Reactor Building will not exceed 122 °F during the one hour it takes plant operations to start the AAC. In particular the applicant noted that "it takes many hours to reach the steady state condition of 121 ºF." As a result, these statements and the supporting analysis and calculation provide reasonable assurance the temperatures will remain below the EQ limits. As a result, the staff found the applicant's response acceptable. The staff **closed both RAI 849-63, Question 09.04.01-12, and its follow-up RAI 327-2401, Question 09.04.01-4.**

The staff noted that from its review of Table 8.3.1-6 "Electrical Load Distribution – AAC GTG Loading (SBO Condition)," it is not clear that the components necessary to maintain the MCRE within the "Abnormal Condition" design temperature limits of Table 9.4-1 (Sheet 1 of 3) are powered by the AAC. The staff requested that the applicant provide additional information that confirms that all necessary controls, instrumentation and components of the MCR HVAC AHUs are powered from the AAC. The applicant responded to RAI 849-63, Question 09.04.01-18 in a letter dated October 03, 2008 (ML082810407), by stating that Table 8.3.1-6 shows only large capacity loads. The MCR HVAC AHUs are powered by AAC. The staff found the response acceptable as it clarifies that the MCR HVAC system is powered by the AAC.

The staff went on to note that the applicant takes credit for one-hour restoration of power via the AAC. Per RG 1.155 (i.e. Criterion 5 of Section 3.3.5) to take credit for the one-hour alignment of the AAC the reliability of the AAC power system should meet or exceed 95 percent as determined in accordance with NSAC-108 (Ref. 11) or equivalent methodology. The staff requested the applicant to demonstrate the reliability of the AAC. After a number of RAIs were exchanged, the applicant responded in a letter dated June 19, 2009 (ML091751095), with a proposal to add an ITAAC item to Tier 1 Table 2.6.5-1 that included acceptance criteria that was based on analysis of the as-built AAC power sources and verified reliabilities of ≥ 95 percent. The staff found the applicant's RAI response and resolution as fundamentally acceptable.

However, the staff found the ITA in ITAAC Table 2.6.5-1 too vague and that analysis alone was not sufficient. The staff issued RAI 475-3780, Question 09.04.01-14. The staff requested that the applicant change the ITA to provide the precise requirements of the ITAAC. The applicant responded in a letter dated November 20, 2009 (ML093290031), with its intent to evaluate GTG reliability based on its industry experience data of starting and loading/running of GTGs. After a number of RAIs, the applicant responded in a letter dated July 16, 2010 (ML102010040), with a mark-up of ITAAC Item 12 of Table 2.6.5-1 of Tier 1 ITAAC with an ITA that requires that a site acceptance test be performed to demonstrate both the capability and the reliability of the as-built AAC power sources to perform their required function.

The staff found the applicant's response acceptable since the proposed ITAAC Item 12 would satisfy the intent of RG 1.155, Section 3.3.5. The staff notes that Revision 3 of the US-APWR DCD Tier 1 deleted Item 12 from Table 2.6.5-1 leaving this as **OPEN ITEM -- RAI 849-63, Question 09.04.01-18; RAI 475-3780, Question 09.04.01-14.** The staff issued **RAI 6063, Question 09.04.01-30, Open Item 09.04.01-30** requesting additional information about the deletion of Item 12 from Table 2.6.5-1. As of the writing of this SER, the staff was in discussion with applicant about further substantiating the reason for this deletion.

10 CFR 52.47(b)(1) – Inspections, Tests, Analyses, And Acceptance Criteria

The regulatory requirements in 10 CFR 52.47(b)(1) are partially addressed by the staff in this section of the SER and are further addressed in DCD Section 14.3.7, "Plant Systems – Inspections, Tests, Analyses, and Acceptance Criteria."

The staff noted in RAI 849-63, Question 09.04.01-27 that DCD Section 9.4.1.4 "Testing and Inspection Requirements" indicates that the standby AHUs are periodically tested for operability.

SR 3.7.10.5 of TS 3.7.10 “Main Control Room HVAC System (MCRVS)” read “Verify two MCRATCS trains have the capacity to remove the assumed heat load”. The staff also noted that the extremes in local weather conditions at each COL site form part of the bases for the “assumed heat load” of SR 3.7.10.5. The Bases for SR 3.7.10.5 read “*This SR verifies that the heat removal capability of the system is sufficient to remove the heat load assumed in the safety analyses in the control room.*” In addition, the staff found that the way SR 3.7.10.5 and its Bases read was open to interpretation. Succinctly, the staff believed the SR needed to verify that each of the four AHU trains remove ≥ 50 percent of the “assumed heat load” on a 24-month basis. The staff requested that the applicant clarify the wording of SR 3.7.10.5 and its Bases.

After a number of RAIs, the applicant amended DCD Chapter 16, TS and the Bases for SR 3.7.10.5. In particular, DCD Revision 3 Bases for SR 3.7.10.5 opens with the words “*This SR verifies that the heat removal capability of all potential operating configuration of two trains of 50 percent capacity MCRATCS air handling units is sufficient to remove the heat load assumed in the safety analyses in the control room. This SR consists of a combination of testing and calculations*.” The staff found the applicant’s response on November 20, 2009 (ML093290031), acceptable since the TS and the Bases for SR 3.7.10.5 fulfill the intent of the SRs for the MCR HVAC system as identified in NUREG-1431 for SR 3.7.11.1. Based on this the staff **closed RAI 849-63, Question 09.04.01-27; RAI 327-2401, Question 09.04.01-8; and RAI 475-3780, Question 09.04.01-12.**

The staff noted in RAI 849-63, Question 09.04.01-24, that DCD Section 9.4.1.4 “Testing and Inspection Requirements” did not contain the design basis flow rates to the particular areas of the CRE that: (1) ensures positive pressures (i.e. ≥ 0.125” w.g. relative to all adjacent areas outside the MCRE); and (2) ensures proper air mixing and (3) ensures uniform temperatures throughout the MCRE. After a number of RAIs were exchanged the applicant provided additional detail in the DCD. Additionally, the applicant provided an ITAAC that resolved all issues. The staff notes that the revision of line item 4.a of ITAAC Table 2.7.5.1-3 per RAI 184-1912, Question 14.03.07-26, (ML091040177) effectively resolves the staff’s concern in that the ITAAC ensure that the design basis for the MCR HVAC system will be satisfied. The staff verified that Revision 3 of the US-APWR DCD included the changes of Table 2.7.5.1-3 for line item 4.a. Based on this, the staff **closed RAI 849-63, Question 09.04.01-24, and RAI 327-2401, Question 09.04.01-7.**

In RAI 849-63, Question 09.04.01-21 the staff noted from its DCD review, that DCD Section 9.4.1.4. “Testing and Inspection Requirements” provides inadequate information about the procedures used to detect and correct component operational degradation. The staff requested in RAI 849-63, Question 09.04.01-21 that the applicant provide additional information for both system performance attributes. The applicant responded in a letter dated October 03, 2008, (ML082810407) with additional information on the testing and inspection. The applicant closed its response with a revision to DCD Revision 1 Subsection 9.4.1.4 that provided clarity and understanding. Since these changes provide a comprehensive license holder requirement to detect and correct component operational degradation during plant operations, the staff found the applicant’s proposed changes to Subsection 9.4.1.4 acceptable.

The staff verified that Revision 3 of the DCD contained the requisite changes and **closed-- RAI 849-63, Question 09.04.01-21.**

9.4.1.5 Combined License Information Items

Staff reviewed the COL information items listed in US-APWR DCD Tier 2 Section 1.8.2 and found that there are two relevant COL Items remaining in Revision 1 of DCD Section 9.4.1. The staff concluded that this is appropriate, but additional COL items associated with the remaining open items may be recommended based upon the final resolution of these open items.

In Table 1.8-2 list of COL items in US-APWR DCD, Revision 3 the Section 9.4 COL items 9.4(1), (2), (3), and (5) were deleted. COL Information Items 9.4(4) and 9.4(6) were unchanged from DCD, Revision 2.

The following is a list of item numbers and descriptions from Table 1.8-2 of the US-APWR DCD. The table was augmented to include "action required by COL applicant/holder."

Table 9.4.1-1
US-APWR Combined License Information Items

Item No.	Description	Section
9.4-4	The COL applicant is to determine the capacity of cooling and heating coils that are affected by site-specific conditions.	9.4.1
9.4-6	The COL Applicant is to provide a system information and flow diagram of ESW pump area ventilation system if the ESW pump area requires the heating, ventilating and air conditioning.	9.4.1

There were no other COL information items not identified in Table 1.8-2 of the US-APWR DCD that should have been identified.

9.4.1.6 Conclusions

As set forth in subsections 9.4.1.2, 9.4.1.3, 9.4.1.4, and 9.4.1.5 of this SER, the US-APWR MCR HVAC System serves safety-related functions and thus has a safety design basis.

The staff evaluated the MCR HVAC System for the US-APWR DCD standard plant design in accordance with guidance that is referred to in the technical evaluation section of this SER. Based on this review, the staff concludes that sufficient information has been provided by the applicant in the US-APWR DCD Tier 1 Subsections 2.7.5.1 and the DCD Tier 2 Section 9.4.1. In addition, staff compared the design information in the DCD application to the relevant NRC regulations, acceptance criteria defined in NUREG-0800 - SRP Section 9.4.1, and other NRC RGs. In conclusion, the US-APWR DCD for the MCR HVAC systems are acceptable and meet the requirements of 10 CFR Part 50, Appendix A, GDC 2, 4, 5, 19 and 60 and 10 CFR 52.47(b)(1), 10 CFR 50.63 and 10 CFR 52.80(a) and the guidelines of SRP Section 9.4.1 with the exception of the following four open item series:

- **Open Item -- RAI 849-63, Question 09.04.01-6; RAI 582-4456, Question 09.04.01-23; RAI 689-4976, Question 09.04.01-26; and RAI ID 6063, Question 09.04.01-29, Open Item 09.04.01-29.**

- **Open Item -- RAI 849-63, Question 09.04.01-18; RAI 327-2401, Question 09.04.01-6; RAI 475-3780, Question 09.04.01-14; RAI 582-4456, Question 09.04.01-20; and RAI 6063, Question 09.04.01-30, Open Item 09.04.01-30.**

- **Open Item -- RAI 849-63, Question RAI 09.04.01-9; MHI RAI 327-2401, Question 09.04.01-3; & RAI 475-3780, Question 09.04.01-13; RAI 582-4456, Question 09.04.01-19; RAI 689-4976, Question 09.04.01-27; and RAI 6063, Question 09.04.01-31, Open Item 09.04.01-31.**

- **Open Item -- RAI 849-63, Question 09.04.01-8; RAI 582-4456, Question 09.04.01-18; RAI 689-4976, Question 09.04.01-25; and NRC RAI 6063, Question 09.04.01-32, Open Item 09.04.01-32.**

In addition, the staff has the following confirmatory items:

- **RAI 689-4976, Question 09.04.01-26 (Parts 2 and 3), Confirmatory Items 09.04.05-26 (Parts 2 and 3)**

- **The series RAI 849-63, Question 09.04.01-14; RAI 327-2401, Question 09.04.01-5; RAI 642-4770, Question 09.04.01-24; NRC ID RAI 5999, Question 09.04.05-21; and RAI 5999, Question 09.04.05-21, Confirmatory Item 09.04.05-21.**

With the exception of these four open items and two NRC confirmatory items, all applicant responses to the staff's RAIs and revisions to the US-APWR DCD have acceptably resolved the staff concerns and are closed. Revision 3 of the DCD is acceptable subject to the completion and closure of the open items and NRC confirmatory item listed above and normal progression and completion of the existing and potential COL items in SER Section 9.4.1.5.

All questions have been resolved and the staff concludes that this section meets the guidance in SRP Section 9.4.1 subject to completion of the above listed open items and confirmatory item. The applicant has provided sufficient information confirming the MCR heating, ventilating and refrigeration systems ability to maintain safety, stable HVAC, permit personnel access and control of the environment during normal operation and AOOs (pending resolution of the open and confirmatory item above). Accordingly, the staff concludes that the applicant (meets or does not meet) the relevant requirements of 10 CFR Part 50, Appendix A, GDC 2, 4, 5, 19 & 60; 10 CFR 52.47(b)(1), 10 CFR 50.63 and 10 CFR 52.80(a) and (is or is not) acceptable.

9.4.2 Spent Fuel Pool Area Ventilation System (Related to RG 1.206, Section C.III.1, Chapter 9, C.I.9.4.2, "Spent Fuel Pool Area Ventilation System")

9.4.2.1 Introduction

The US-APWR DCD Chapter 9.4.2 indicates that the ventilation for the SFP area is addressed in Section 9.4.3, "Auxiliary Building Ventilation System." The staff evaluated Sections 9.4.2 and 9.4.3 against NUREG-800 Section SRP 9.4.2 "Spent Fuel Pool Area Ventilation System."

The AB ventilation system provides the ventilation environmental controls during normal operations for the AB, RB, PSB, and AC/B, (except for the CRE, and Class 1E electrical rooms). This coverage includes the SFP area.

9.4.2.2 Summary of Application

Revision 3 of the US-APWR DCD Chapter 9.4.2 consists, in its entirety, of the statement "*The spent fuel pool area in the reactor building is serviced by the auxiliary building HVAC system. Ventilation for the spent fuel pool area is addressed in Section 9.4.3.*"

The AB ventilation system is classified as a nonsafety-related, non-Seismic Category I system, with the exception of containment isolation damper assemblies. The safety-related, Seismic Category I isolation dampers close during a DBA and are addressed under Section 9.4.3. Also addressed under Section 9.4.3 is the design of the required system ductwork that will prevent adverse interaction with safety-related systems during seismic events.

With respect to the SPF area ventilation, a nonsafety-related status is based on the Accident Analysis 15.7.4, "Fuel Handling Accident." This accident analysis states that the air cleanup and water cleanup systems are available and expected to function during this event, but are not credited for mitigation of dose consequences to the public. The resulting calculated offsite doses for this accident are below 25 rem TEDE.

ITAAC: No unique ITAAC (beyond those listed under DCD Tier 2 Sections 9.4.3 and 14.2.12.1.99) are required for the SFP area portion of the AB ventilation system.

TS: There are no TS associated with the SFP area of the AB ventilation system.

9.4.2.3 Regulatory Basis

The relevant requirements of the Commission regulations for this area of review and the associated acceptance criteria are given in Section 9.4.2 of NUREG-0800 and are summarized below.

- GDC 2, "Design Bases for Protection Against Natural Phenomena," as related to the system and its components important to safety being capable of withstanding the effects of natural phenomena such as earthquakes, tornados, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions.

- GDC 5, "Sharing of Structures, Systems, and Components," as related to SSCs important to safety.

- GDC 60, "Control of Release of Radioactive Materials to the Environment," as related to the system capability to suitably control release of gaseous radioactive effluents to the environment during normal reactor operation, including AOOs.

- GDC 61, "Fuel Storage And Handling And Radioactivity Control," as related to the system's capability to provide appropriate containment, confinement, and filtering to limit releases of airborne radioactivity to the environment from the fuel storage facility under normal and postulated accident conditions.

- GDC 64, "Monitoring Radioactivity Releases," which requires that means be provided for monitoring the reactor containment atmosphere, spaces containing components for recirculation of LOCA fluids, effluent discharge paths, and the plant environs for radioactivity that may be released from normal operations, including AOOs, and from postulated accidents.

- 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 facility that incorporates the DC is built and will operate in accordance with the design certification, provisions of the Atomic Energy Act of 1954, and NRC regulations.

9.4.2.4 Technical Evaluation

The staff reviewed DCD Tier 1 and 2 information related to DCD Sections 9.4.2 and 9.4.3, in accordance with NUREG-800 SRP Section 9.4.2 to ensure that the relevant requirements of GDC 2, 5, 60, 61, and 64, and 10 CFR 52.47(b)(1) are met. The staff's technical evaluation of these requirements follows.

Summary of RAI Exchange

As part of the staff evaluation during the DCD review process, an initial RAI 65-844 containing six questions was prepared and sent to the applicant. Given below are: (a) the RAI 64-844, Question 9.04.02-1 and RAIs 9.4.2-1 through -6 along with the applicant's responses dated October 03, 2008 (ML082810406); (b) any subsequent RAI questions and responses ML091460119 - RAI 328-2436; ML100960032 - RAI 539-4329; and ML101930163 – RAI 592-4673, Question 09.04.02-6 and ML11284A036 – RAI 824-6022, Question 09.04.02-7; and (c) the staff evaluation for disposition of these RAI questions. The staff compressed the RAI question and the applicant's response from the complete version where practical.

9.4.2.4.1 General Design Criterion 2

The staff reviewed the SFP portion of the applicant's AB ventilation system to ensure that the relevant requirements of 10 CFR 50 Appendix A GDC 2 are met. This includes the system's capability to withstand the effects of natural phenomena by meeting the guidelines of RG 1.29, "Seismic Design Classification," Position C.1 for essential safety-related portions of the system and Position C.2 for nonessential nonsafety-related portions of the system. Since this portion of the ventilation system contains only nonsafety-related equipment, RG 1.29 Position C.1 is not applicable. RG 1.29 Position C.2 for nonsafety-related SSCs is satisfied by having all equipment and ductwork within areas containing safety-related equipment supported as Seismic Category II.

Based on the systems' design bases, the staff finds that the SFP portion of the applicant's AB ventilation system is nonsafety-related. Failure of the SFP portion of the applicant's AB ventilation system or its components due to natural phenomena cannot have adverse effects on safety-related SSCs. Therefore, the staff finds that the SFP portion of the applicant's AB ventilation system does not need to meet the requirements of GDC 2.

Criterion 2 of 10 CFR 50, Appendix A, maintains that SSCs important to safety must be able to withstand the effects of natural phenomena such as earthquakes, tornados, hurricanes, floods, tsunami, and sieches without loss of capability to perform their safety functions. SRP 9.4.2 Section II, "Technical Rationale," ensures that any fuel damage event in the SFP area will not result in potential offsite doses in excess of 0.5 rem to the whole body.

To better understand the design of the SFP portion of the US-APWR AB ventilation system, in RAI 64-844, Question 09.04.02-1, the staff requested that the applicant provide the details and logic of how the SFP portions of the AB ventilation system meet GDC 2.

The applicant responded in a letter dated October 03, 2008 (ML082810406), that there is no separate SFP ventilation system, but that the fuel handling area ventilation in the RB is part of the AB HVAC system as shown in DCD Tier 2, Figure 9.4.3-1. The spent fuel storage pit is located within the fuel handling area, which is part of the RB as a Seismic Category I structure. The AB HVAC system meets GDC 2, by compliance with RG 1.29, Position C.1 for safety-related portions and Position C.2 for nonsafety-related portions. Almost all AB HVAC system components are designed as nonsafety-related. The exceptions are the safety-related isolation dampers such as the penetration area supply and exhaust line isolation dampers, the safeguard component area supply and exhaust isolation dampers, and the AB exhaust line isolation dampers. However, all equipment and ductwork within areas containing safety-related equipment will be supported as Seismic Category II and the safety-related isolation dampers and associated ductwork are supported as Seismic Category I. The AB will maintain its structural integrity after a SSE. The applicant revised the DCD to provide a more comprehensive description of the design and operation for the fuel handling area ventilation portion of the AB HVAC system. The applicant's changes in DCD Revision 3 for Subsection 9.4.3.1 included identification that the design basis has the nonsafety-related equipment and ductwork within areas containing safety-related equipment supported as Seismic Category II. In addition, Revision 3 identifies the safety-related isolation dampers and associated ductwork supported as Seismic Category I. The staff found the applicant's response fully addressed how the SFP portions of the AB ventilation system satisfy the relevant requirements of GDC 2. Based on this the staff found the response acceptable and **closed RAI 65-844, Question 09.04.02-1, Question 1**.

Based on the staff's review of Revision 3 of the DCD, the foregoing RAI exchange and DCD enhancements, the staff concluded that the SFP portion of the applicant's AB ventilation system as described in the US-APWR DCD satisfies the requirements of GDC 2.

9.4.2.4.2 General Design Criterion 5

The basis for GDC 5 acceptance is that an accident in one unit does not significantly affect the capability to conduct a safe and orderly shutdown and cool-down of the remaining unit(s). The staff reviewed the SFP portion of the applicant's AB ventilation system against the requirements of GDC 5. Since the design application is for a single unit plant, GDC 5 does not apply to this system.

9.4.2.4.3 General Design Criterion 60

The staff reviewed the design of the SFP portion of the AB ventilation system for compliance with the relevant requirements of GDC 60. The guidance for GDC 60 is based on RGs 1.52 and 1.140. RG 1.52 is not applicable to the SFP area ventilation system because it is not required to operate for post-accident ESF atmospheric cleanup. RG 1.140 is applicable to the design, inspection, testing, and maintenance criteria for normal atmosphere cleanup systems, ventilation exhaust systems, air filtration, and absorption units. The AB ventilation system does not contain a filtration or cleanup system, but has a detection and diversion capability to the containment low-volume purge exhaust system. The AB ventilation system complies with the intent of RG 1.140 by monitoring airborne radiation in the exhaust duct, providing an alarm to alert on high radiation, and having a manual exhaust diversion to a separate compliant system.

In RAI 65-844, Questions 09.04.02-1, Question 2, the staff requested additional information from the applicant justifying the conclusion that the SFP ventilation system is not required to meet the requirements of: (a) GDC 60; (b)10 CFR Part 20 for normal operation and AOOs; or (c) 10 CFR 50 Appendix I requirements.

The applicant responded in a letter dated October 03, 2008 (ML082810406), that the SFP area is normally ventilated by the AB HVAC AHU supply fans and the unfiltered air is exhausted by the AB HVAC exhaust fans. Under normal operation, the unfiltered exhaust air is continuously monitored for airborne radiation and is exhausted by the exhaust fans via the plant vent stack. When the radiation monitors sense higher-than-allowed limits, alarms are activated and the SFP area is manually isolated from the AB HVAC system, and the exhaust is manually directed from the AB HVAC system to the containment low-volume purge exhaust system, where the exhaust air passes through a filtration unit that includes a HEPA filter and a charcoal adsorber.

The applicant further responded that the current design of the AB HVAC system satisfies the dose evaluation during normal operation and AOOs as described in DCD Revision 1, Subsections 11.3.3 and 12.4. By monitoring airborne radiation in the exhaust duct, providing an alarm to alert on high radiation, and having a manual diversion to the containment low-volume purge exhaust system, this function enables the system to comply with GDC 60 requirements without a separate cleanup system. The containment low-volume purge exhaust system meets the GDC 60 requirements based on the compliance with RG 1.140. Therefore, MHI concluded the AB HVAC system is not required to meet the GDC 60.

The applicant revised the AB HVAC system description to address GDC 60 requirements for normal plant operations. During the staff's review of Revision 3 of the DCD, the staff verified that Subsection 9.4.3.2.1 reflects the change specified in the applicant's response to RAI 939-4329, Question 09.04.02-5. In contrast, the staff noted that the applicant failed to revise Table 1.9.2-9 "US-APWR Conformance with Standard Review Plan Chapter 9 Auxiliary Systems" with the changes proposed by the applicant. Based on this, the staff holds open as **Confirmatory Item -- RAI 65-844, Question 09.04.02-1, Question 2 and RAI 939-4329, Question 09.04.02-5, Confirmatory Item 09.04.02-5**. The staff issued follow-up RAI 6022, Question 09.04.02-7 to track this missing DCD amendment and to prompt further applicant action.

The staff noted during the review the guidance of SRP 9.4.2 Section III.3.D, "Review Procedures," reads in part: "… for each spent fuel pool area ventilation system component or subsystem affected by the loss of offsite power (LOOP), the resulting system flow capacity will not cause the loss of preferred direction of air flow from areas of low potential radioactivity to areas of higher potential radioactivity."

In RAI 65-844, Question 09.04.02-1, Question 4, the staff noted that Table 8.3.1-5, "Electrical Load Distribution-AAC GTG Loading (LOOP Condition)," does not list any of the AB ventilation systems as a LOOP load. The staff asked the applicant whether any of the MCCs listed on Table 8.3.1-5 (i.e., P11, P12, P21, and P22) supply power during a LOOP to any other AB ventilation system besides the non-class 1E electrical room HVAC system and the TSC HVAC system.

The applicant responded that the AB HVAC system is not safety-related and is not required to operate during LOOP Condition for a DBA. The postulated accident event for the fuel handling area is the fuel handling accident described in DCD Section 15.7.4. The analysis assumes that, after the radionuclides leave the water, they are released directly to the environment over a two-hour period with no credit for any filtration. Calculated doses at the EAB and LPZ outer boundary are below the dose limits for 10 CFR 50.34.

The applicant revised the DCD to describe the design and operation of the fuel handling area ventilation portion of the auxiliary building HVAC system. The staff found the response acceptable since the guidance from SRP 9.4.2 Section III.3.D is not relevant. Based on this, staff **closed RAI 65-844, Question No.09.04.02-1, Question 4.**

Based on the staff's review of Revision 3 of the DCD, the foregoing RAI exchanges and DCD enhancements including closure of the lone confirmatory item, the staff concluded that the SFP portion of the applicant's AB ventilation system as described in the US-APWR DCD satisfies the requirements of GDC 60.

9.4.2.4.4 General Design Criterion 61

The staff reviewed the design of the SFP portions of the AB ventilation system for compliance with the relevant requirements of GDC 61. The design was reviewed to ensure that releases of radioactive materials during normal operation, AOOs, and postulated accidents will not result in radiation doses in excess of the limits specified in 10 CFR Part 20. The SFP area ventilation system is not credited for mitigation of the postulated SFP area AB building ventilation system meets the GDC requirements by monitoring airborne radiation in the exhaust duct, providing a MCR alarm to alert on high radiation, and having a manual exhaust diversion to the attendant RG 1.140 compliant filter trains of the containment low-volume purge exhaust system. To establish that the relevant requirements for GDC 61 were considered in the design of SFP ventilation, the staff requested additional information in RAI 65-844, Question 09.04.02-1, Question 3, in two parts:

First, the staff noted that DCD Section 9.4.3 "Auxiliary Building Ventilation System" had no discussion on how the design of the SFP ventilation system satisfied the requirements of 10 CFR 50 Appendix A Criterion 61. In particular, the staff invoked the review criteria of SRP 9.4.2 II, Technical Rationale 4.

The staff went on to note that DCD Section 15.7.4, "Fuel Handling Accident," contained the following passage:

"Air cleanup and water cleanup systems are available and expected to function during this event, but are not credited for mitigation of dose consequences to the public because these systems are not engineered safety features. The fuel handling accident is classified as a postulated accident (PA) event."

The staff observed that, in contrast to this excerpt from Section 15.7.4, there is no display of a non-ESF air filtration cleanup system in Figure 9.4.3-1, "Auxiliary Building HVAC System Flow Diagram," nor is it detailed in DCD Section 9.4.3, "Auxiliary Building Ventilation System."

The staff requested that the applicant provide the basis for meeting GDC 61 without including a non-ESF air filtration and adsorption unit (i.e. per RG 1.140) in the US-APWR design to process the exhaust ventilation from the AB HVAC system.

The staff requested that the applicant provide additional information and a justification for the current design in that the SFP ventilation system does not meet the specific Criterion 61 requirement to limit releases of radioactive materials during normal operation, AOOs, and postulated accidents to radiation doses less than the limits specified in 10 CFR Part 20. The staff went on to request that the applicant include in its response a discussion of how the current design of the AB HVAC system satisfies the requirements of 10 CFR 50.34a and Appendix I to the same part.

In its response dated October 03, 2008 (ML082810406), the applicant described how the two ventilation systems (AB HVAC system and containment low-volume purge system) interface and operate together so that the two systems meet GDC 60 and GDC 61 requirements for normal plant condition. In the postulated accident condition, as described in DCD Tier 2 Section 15.7.4, the ventilation system is not credited in the dose evaluation of a fuel handling accident. Thus, the ventilation system is not required to meet GDC 61 requirements for postulated accident conditions. In this regard, the staff found the applicant's response acceptable.

Second, the staff also referred to a passage in DCD Section 12.3.3.3 that provides guidelines to minimize personnel exposure from HVAC equipment. These guidelines include: (a) the use of RG 8.8 as practicable in the design of the plant ventilation systems; (b) designing ventilation ducts to minimize the buildup of radioactive contamination within the ducts; and (c) recirculation of ventilating air only in areas outside the RCA and filtration and subsequent discharge of exhausted air from potentially contaminated areas in the RCA.

The staff noted there was no discussion within DCD Section 9.4.3 for any of the potentially contaminated areas of Figure 9.4.3-1 (i.e., Fuel Handling Area, RB Controlled Area, AB Controlled Area, AC/B Controlled Area) of how the design of the ventilation ducts will minimize the buildup of radioactive contaminants within the ducts.

With respect to achieving the ALARA goals per the guidance of 10 CFR 50 Appendix I, the staff requested that the applicant include a discussion in DCD Section 9.4.3 of how the design of the ventilation ducts will minimize the buildup of radioactive contaminants within the ducts.

The applicant responded that to minimize the buildup of radioactive contamination within the ducts, the exhaust ducts are design/sized for the transport velocities needed to convey the radioactive contaminants without settling. Ducts for most nuclear exhaust and post-accident air cleanup systems should be sized for a minimum duct velocity of approximately 2,500 feet per minute. Ducts shall also meet the requirements of ASME AG-1, Section SA, and SMACNA's "HVAC System-Duct Design."

In concluding its response dated October 03, 2008 (ML082810406), the applicant proposed a revision of the DCD to describe the system design and operation with respect to meeting the GDC 61 requirements for normal operation. The staff verified that in DCD Revision 3 the applicant had amended the auxiliary building HVAC system description to address GDC 61 requirements for normal plant operations. Based on this, the staff found the applicant's response acceptable and **closed RAI 65-844, Question 09.04.02-1, Question 3.**

Based on the staff's review of Revision 3 of the DCD, the foregoing RAI exchange and DCD enhancements, the staff concluded that the SFP portion of the applicant's AB ventilation system as described in the US-APWR DCD satisfies the requirements of GDC 61.

9.4.2.4.5 General Design Criterion 64

The staff’s review and final assessment of GDC 64 requirements for monitoring the effluent discharge paths for radioactivity that may be released from normal operations, AOOs, and postulated accidents in the SFP area is consigned to Section 11 of this SER.

The staff requested additional information in RAI 65-844, Question 09.04.02-1, Question 6 and subsequent RAI 328-2436, Question 09.04.02-3, with respect to the US-APWR design meeting the 10 CFR 50, Appendix A, Criterion 64 requirement for monitoring the effluent discharge paths from the SFP area during normal operations, AOOs, and from postulated accidents as applicable to the review of DCD Section 11.5.

The applicant responded in a letter dated May 21, 2009 (ML091460119), that the effluent paths from the plant that are radioactive or have the potential of becoming radioactive from cross-contamination are monitored and the radiation monitors are identified and described in DCD Section 11.5, "Process Effluent Radiation Monitoring and Sampling Systems." This system is designed to perform its monitoring and recording functions during normal operation, AOOs, and under post-accident conditions. The applicant proposed to revise Tier 2 DCD Section 9.4.3.2.1 to reflect this.

The staff found the applicant’s response acceptable since the revised DCD documents the provision for monitoring of the ventilation effluent paths from the SFP area during all plant modes of operation. The staff verified that Revision 3 of the DCD contained the changes proposed by the applicant. Based on this, the staff **closed RAI 65-844, Question 09.04.02-1, Question 6 and RAI 328-2436, Question 09.04.02-3.**

Based on the staff’s review of Revision 3 of the DCD, the foregoing RAI exchanges and DCD enhancements, the staff concluded that the SFP portion of the applicant’s AB ventilation system as described in the US-APWR DCD satisfies the requirements of GDC 64.

9.4.2.4.6 10 CFR 52.47(b) (1) Operations and Testing Evaluation

The staff reviewed the SFP portion of the AB ventilation system to ensure that the DCD addressed the ITAAC requirements of 10 CFR 52.47(b)(1). Compliance with 10 CFR 52.47 requires that a DC application contain proposed ITAAC that are necessary and sufficient to provide reasonable assurance that a facility which incorporates the DC is built and will operate in accordance with the design commitments and meet the applicable NRC regulations.

The staff reviewed the ITAAC to ensure that the as-built system will comply with the approved system design of the DCD. The staff noted that there was no Tier 1 ITAAC section devoted specifically to the SFP portion of the AB ventilation system. Tier 1 Section 2.7.5.4.2 and Table 2.7.5.4-3 in particular identify the ITAAC requirements for the AB ventilation system.

The requirements in 10 CFR 52.47(b)(1) related to this section are also supported by SER Sections 9.4.3, "Auxiliary Building Ventilation System," and 14.3.7, "Plant Systems – Inspections, Tests, Analyses, and Acceptance Criteria."

In RAI 65-844 Question 09.04.02-1, Question 5 and follow-on RAI 328-2436, Question 09.04.02-2, the staff requested the applicant to add the design basis parameters to the DCD. The staff noted that there were a number of important pieces of information or parameters not included in the preoperational testing. Specifically the staff requested the following additional information with respect to the design bases and guidelines including, ventilation supply/exhaust paths, design basis supply and exhaust for the fuel handling area.

The applicant provided the information in its response dated May 21, 2009 (ML091460119) including clarification of the fuel handling area boundary, supply and exhaust design flow rates and HVAS service to different radiological controlled areas. Supply rates were shown to be less than exhaust rates supporting the needed negative pressure condition.

The staff notes that the flow parameters included in the applicant's responses appear to be reasonable in achieving the desired radiological effects as described above in DCD Sections 9.1.2.2.2, 9.4.3.1.2.1 and 12.3.3.3. Each COL applicant will verify, via completion of DCD Section 14.2.12.1.99 "Auxiliary Building HVAC System Preoperational Test," that the desired pressure differentials and radiological effects of DCD Sections 9.1.2.2.2, 9.4.3.1.2.1 and 12.3.3.3 are satisfied. The staff finds this acceptable.

In follow-up RAI 539-4329, Question 09.04.02-4 the staff noted that the applicant failed to revise the DCD with the collective information provided to the staff in the RAI responses above. The applicant responded in a letter dated April 01, 2010 (ML100960032), to follow-up RAI 539-4329, Question 09.04.02-4 with a proposed revision of DCD Figure 9.4.3-1 and DCD Subsection 9.4.3.2.1 with changes that would resolve the staff's outstanding concerns with issues. The staff verified that Revision 3 of the DCD contained the changes to Figure 9.4.3-1 and subsection 9.4.3.2.1.

The staff still found the applicant's response to RAI 539-4329, Question 09.04.02-4 incomplete since the applicant failed to adequately revise Table 12.2-60 by emphasizing that the exhaust flow rates were minimum flow values to maintain RB airborne radioactive concentrations at acceptable levels.

In addition, the staff found that 14.2.12.1.99 "Auxiliary Building HVAC System Preoperational Test" did not require the COL applicants to satisfy the flow rate requirements of Table 12.2.60. In RAI 592-4673, Question 09.04.02-6 the staff requested that the applicant remedy these deficiencies. The applicant responded July 07, 2010 (ML101930163), revising both Table 12.2.60 "Parameters and Assumptions for Calculating Airborne Radioactive Concentrations (Reactor Building and Auxiliary Building)" and Section 14.2.12.1.99 "Auxiliary Building HVAC System Preoperational Test." The staff verified that Revision 3 of the DCD contained both of these changes. This brought closure to all the issues associated with the staff's 10 CFR 52.47(b)(1) review of the SFP area ventilation system. Accordingly, the staff **closed RAI 65-844, Question 09.04.02-1, Question 5; RAI 328-2436, Question 09.04.02-2; RAI 539-4329, Question 09.04.02-4; and RAI 592-4673, Question 09.04.02-6**.

9.4.2.5 Combined License Information Items

The staff reviewed the COL information items as listed in Revision 3 of the DCD Tier 2 Table 1.8-2 and Section 9.4.7. The staff found that there are no items relevant to the SFP area portion of the AB ventilation system. The staff concluded that this is appropriate and no COL information items are needed for the SFP area portion of the AB ventilation system.

9.4.2.6 Conclusions

As set forth in Sections 9.4.2.3 and 9.4.2.4 of this SER, the US-APWR fuel pool area portion of the AB ventilation system does not serve any safety-related function, and thus has no safety design basis.

The staff evaluated the fuel pool area portion of the AB ventilation system for the US-APWR standard plant design in accordance with the guidance of Section 9.4.2.3 of this SER. Based on this review, staff concluded that the applicant provided sufficient information in the US-APWR DCD: Tier 1 Section 2.7.5.4; Tier 2 Section 9.4.2; Tier 2 Section 9.4.3; and Tier 2 Subsection 14.2.12.1.99. In addition, staff compared the design information in the DC application to the relevant NRC regulations, acceptance criteria defined in NUREG-0800, SRP Section 9.4.2, and other NRC RGs. In conclusion, the US-APWR design for the fuel pool area portion of the AB ventilation system is acceptable and meets the requirements of GDC 2, 5, 60, 61, 64 and 10 CFR 52.47(b)(1) and the guidelines of SRP Section 9.4.2 for protection against natural phenomena and control of releases of radioactive materials to the environment.

The staff closed RAI 65-844, Question 09.04.02-1, Questions 1, 3, 4, 5 and 6.

The staff carries forward into Phase IV, RAI 65-844, Question No. 09.04.02-1, Question 2 with follow-up RAI 6022, Question 09.04.02-7 as **Confirmatory Item, 09.04.02-7**.

The staff concludes that this section meets the guidance in SRP Section 9.4.2 subject to the closure of the one NRC confirmatory item. The applicant provided sufficient information confirming the spent fuel area portion of the AB ventilation system's ability to maintain ventilation, permit personnel access, and control the release of airborne radioactive material to the environment during normal operation and AOOs. As stated above, the staff concluded that the application meet the relevant requirements of 10 CFR Part 50, Appendix A and GDC 2, 5, 60, 61 and 64 and is acceptable.

9.4.3 Auxiliary and Radwaste Area Ventilation System (Related to RG 1.206, Section C.III.1, Chapter 9, C.I.9.4.3, “Auxiliary and Radwaste Area Ventilation System”)

9.4.3.1 Introduction

This section evaluates US-APWR DCD Section 9.4.3 AB ventilation system. The function of the AB Ventilation System (ABVS) is to provide proper environmental conditions during normal plant operation for all areas of the AB, RB, PSB and the AC/B with the exception of the CRE, and the Class 1E electrical rooms. The ABVS does not include the MCR HVAC system addressed in Section 9.4.1 or the HVAC systems serving the safeguard components actuated during DBAs discussed in Section 9.4.5.

9.4.3.2 Summary of Application

DCD Tier 1: US-APWR DCD Tier 1 Section 2.7.5.4 provides the Tier 1 information associated with the ABVS. Section 2.7.5.4.1.1 of the DCD provides a brief description of the AB HVAC system and states that with the exception of the isolation dampers, the AB HVAC system is a nonsafety-related system. Tier 1 Section 2.7.5.4.1.2 of the DCD provides a description of the non-Class 1E electrical room HVAC system, which provides conditioning air for the equipment in the electrical rooms. The non-Class 1E electrical room HVAC system is a nonsafety-related system. Tier 1 Section 2.7.5.4.1.3 describes the nonsafety-related main steam/feedwater piping area HVAC system designed to provide conditioning air in the main steam/feedwater piping areas. Tier 1 Section 2.7.5.4.1.4 describes the nonsafety-related TSC HVAC system designed to maintain proper environmental conditions in the TSC.

DCD Tier 2: The US-APWR DCD Tier 2 Section 9.4.3 provides the ABVS design, summarized here, in part, as follows:

The ABVS provides proper environmental conditions during normal plant operation throughout all areas in the AB, RB, PSB and the AC/B. The ABVS includes the AB HVAC system, the non-Class 1E electrical room HVAC system, the main steam/feedwater piping area HVAC system and the TSC HVAC system. The ABVS is classified as a nonsafety-related, non-Seismic Category I system, with the exception of containment isolation damper assemblies. The safety-related, Seismic Category I isolation dampers close during a design basis accident. In addition, support of required ductwork prevents adverse interaction with other safety-related systems during seismic events. The applicant stated that the AB HVAC system satisfies the following safety design bases:

- The AB HVAC system has the capability to close the safety-related, Seismic Category I isolation dampers during a DBA.

- The safety-related isolation damper assemblies isolate the penetration and the safeguard component areas, and the vent stack from the AB HVAC system.

- The isolation damper assemblies connect to separate electrical safety buses that satisfy the single active failure criteria.

- During a DBA, the penetration and safeguard component areas are isolated in order that operations of the annulus emergency exhaust system, described in Section 9.4.5, can maintain a negative pressure and mitigate the release of airborne fission products to the atmosphere.

- During a DBA, the AB HVAC system discharge duct is isolated in order to prevent backflow of discharge air from the annulus emergency exhaust system into the AB HVAC system.

- The isolation damper assemblies can withstand the effects of adverse environmental conditions.

- The ductwork in the RB and PSB will be supported to prevent adverse interactions with safety-related systems during a seismic event. Nonsafety-related equipment and ductwork are supported as Seismic Category II within areas that contain safety-related equipment.

The applicant stated that there are no safety design bases for the non-Class 1E electrical room HVAC system, the TSC HVAC system and the main steam/feed water piping area HVAC system with the exception of required ductwork support to prevent adverse interaction with other safety-related systems during a seismic event. The applicant stated that US-APWR DCD

Section 9.4.5 addresses HVAC systems serving safeguard components, EFW pump, safety-related component areas and the Class 1E electrical room HVAC systems.

The AB HVAC system during power generation satisfies the following design bases: Provide and maintain proper environment within the required temperature range for the mechanical and electrical equipment during normal plant operation. Keep dose levels due to airborne radioactivity below the allowable values set by 10 CFR 20 by supplying and exhausting sufficient airflow. Control the exhaust fan airflow continuously and automatically at a predetermined value to maintain a slightly negative pressure in the controlled areas relative to the outside atmosphere and minimize leakage from the radiological controlled areas during normal plant operation. Maintain airflow from areas of low radioactivity to areas of potentially higher radioactivity. Provide accessibility to system components for adjustment, maintenance and periodic inspection and testing of the system's equipment and components to assure proper equipment function and reliability and system availability. Cross connects between the AB HVAC system and the containment low volume purge system allow exhaust from the radiological controlled areas to be filtered. The exhaust air duct from the controlled areas is monitored for airborne radioactivity (Section 12.3.4.2.8).

The non-Class 1E electrical room HVAC system during power generation satisfies the following design bases: Provide and maintain the room ambient conditions within the required temperature range to support the continuous operation of the electrical equipment and components. Maintain the hydrogen concentration below one percent by volume of battery room. Provide accessibility to system components same as discussed above for the AB HVAC system.

The main steam/feedwater piping area HVAC system during power generation satisfies the following design bases: Provide and maintain proper environmental conditions within the required temperature range suitable to support the operation and assure the reliability of the electrical and mechanical components. Provide accessibility to system components same as discussed above for the AB HVAC system.

The TSC HVAC system during power generation satisfies the following design bases: Exclude entry of airborne radioactivity into the TSC envelope and remove radioactive material from the TSC envelope environment such that radiation doses to personnel are within the requirements of GDC 19. Provide and maintain proper environmental conditions within the required temperature range to assure personnel comfort and to support the operation of the control and instrumentation equipment and components. Support and maintain TSC habitability and permit personnel occupancy following plant emergency conditions. Provide accessibility to system components same as discussed above for the AB HVAC system.

The applicant stated that the AB HVAC system is a filtered once-through type and consists of supply and exhaust air systems. The supply air system includes two AB AHUs, each sized for 50 percent of the total system airflow, and three AB exhaust fans, each sized for 50 percent of the total system airflow. To maintain a slightly negative pressure in the controlled areas, the exhaust fan airflow is continuously and automatically controlled during operation at predetermined values.

ITAAC: Tier 1 Section 2.7.5.4.2 identifies the ITAAC requirements for the ABVS. Tier 1 Table 2.7.5.4-3 depicts these ITAAC.

TS: There are no TS associated with the ABVS. There are TS for the annulus emergency exhaust system given in Tier 2 Chapter 16, Section 3.7.11. During an ECCS actuation signal, the penetration and safeguards components areas are automatically isolated by safety-related Seismic Category I isolation dampers to ensure the annulus emergency exhaust system can maintain a negative pressure. The annulus emergency exhaust system is an ESF filter system addressed in Section 9.4.5.

9.4.3.3 Regulatory Basis

The staff reviewed DCD Tier 1 Section 2.7.5.4 and Tier 2 Section 9.4.3, "Auxiliary Building Ventilation System," in accordance with SRP Section 9.4.3 of NUREG-0800, "Auxiliary and Radwaste Area Ventilation System."

The applicant's ABVS is acceptable if it meets the following requirements:

- GDC 2 – "Design Bases for Protection Against Natural Phenomena," as related to the system and its components important to safety being capable of withstanding the effects of natural phenomena such as earthquakes, tornados, hurricanes, floods, tsunami, and sieches without loss of capability to perform their safety functions.
- GDC 5 – "Sharing of Structures, Systems, and Components," as related to shared systems and components important to safety.
- GDC 60 - "Control of Release of Radioactive Materials to the Environment," as related to the systems capability to suitably control release of gaseous radioactive effluents to the environment.
- 10 CFR 52.47(b)(1), which requires that a DC 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 facility 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 regulations.

Acceptance criteria adequate to meet the above requirements include the following: GDC 2 acceptance is based on the guidance provided in RG 1.29. GDC 5 acceptance is based on the determination that the ABVS installed in a multi-unit facility that shares SSCs will not adversely affect the safe shutdown and cool-down of one unit if the other unit experiences an accident. GDC 60 acceptance is based on the guidance provided in RG 1.52 and RG 1.140 as they relate to the design, inspection, testing and maintenance criteria for post-accident and normal atmosphere cleanup systems, ventilation exhaust systems, air filtration and absorption units of light-water-cooled nuclear power plants.

9.4.3.4 Technical Evaluation

The staff reviewed the ABVS for the US-APWR to confirm conformance with the requirements and acceptance criteria defined in SRP Section 9.4.3. The staff review also addressed the functions to maintain ventilation, permit personnel access, and the controls to maintain the concentration of airborne radioactive material in the AB areas. Discussed below are the results and conclusions of the staff's review of the ABVS.

Summary of RAI Exchange

The staff developed twenty questions during its evaluation of SRP Section 9.4.3. The staff sent these RAIs by letter titled, "Requests for Additional Information No. 68, SRP Section 09.04.03," dated September 8, 2008. The applicant sent its response to the first set of RAIs by letter titled "MHI Responses to US-APWR DCD RAI No. 68," dated October 8, 2008 (ML082840131). The staff developed and sent follow-up RAIs by letter titled, "Request for Additional Information No. 355-2492, SRP Section: 09.04.03," dated May 7, 2009. The applicant sent its response to the follow-up RAIs by letter titled "MHI's Responses to US-APWR DCD RAI No. 355-2492 Revision 1," dated July 17, 2009 (ML092030376). The staff also sent a question on ASME AG-1 Code version issues by letter titled "Request for Additional Information No. 442-3378 Revision 1 SRP Sections 6.4 and 9.4.1 through 9.4.6," dated August 25, 2009. The applicant sent its response to the ASME AG-1 Code issue by letter titled, "MHIs Response to US-APWR DCD RAI No. 442-3378 Revision 1," dated September 18, 2009 (ML092650173). The staff developed and sent follow-up RAIs by letter titled, "Request for Additional Information 483-3885 Revision 1" SRP Section 09.04.03, dated November 9, 2009. The applicant responded to RAI 483-3885 with a letter dated February 5, 2010 (ML100480086). The staff has condensed the RAI questions and answers when possible from the complete version in the response letters from MHI.

9.4.3.4.1 General Design Criterion 2

The staff reviewed the ABVS to ensure it meets the relevant requirements of 10 CFR 50 Appendix A, GDC 2, as related to the design of SSCs important to safety being capable of withstanding the effects of a design basis earthquake. The staff reviewed the ABVS to ensure that the system is capable of withstanding the effects of natural phenomena by meeting the guidelines of RG 1.29, "Seismic Design Classification," Position C.1 for safety-related portions of the system and Position C.2 for nonsafety-related portions of the system.

SRP 9.4.3 Section III.2.A indicates that the P&IDs should clearly indicate the physical divisions between safety-related and nonsafety-related portions and indicate design classification changes. The staff issued a series of RAIs noting that the FSAR did not show the boundaries between Seismic Category I safety-related components and nonsafety-related components. The staff requested that the applicant provide identification of the seismic classification boundaries for the ABVS safety related isolation dampers in these figures. The staff confirmed that the applicant revised the DCD Section 9.4 figures to show the classification changes between Seismic Category I safety-related components and nonsafety-related components. The staff confirmed that Tier 1 Table 2.7.5.4-3 has ITAAC for the seismic qualification of SSCs. Table 2.7.5.4-3 has ITAAC requiring that inspections be performed to confirm that the Seismic Category I isolation dampers are present and that type tests and/or analyses of the Seismic Category I isolation dampers will be performed on the as-built components to ensure they can withstand the seismic design basis loads without loss of safety function. In addition, the information and requirements contained in Tier 1 Section 2.2.4 and Tier 1 Tables 2.2-1 and 2.2-4 (i.e. Design Commitment 23) collectively effectively resolved all but one of the staff concerns of RAI 355-2492, Question 09.04.03-1. As a result, the staff found the applicant's approach acceptable.

The staff also noted in RAI 355-2492, Question 9.4.3-1 that both the AB HVAC system and the main steam/feedwater area HVAC system either contain Seismic Category I components or have components (e.g. AO valves, ducting, etc.) in areas where safety-related Seismic Category I components are located. This system attribute is important to plant safety. Neither of the preoperational tests for these two systems required verification as a prerequisite that Seismic II/I construction was complete and that the DC walkdown was complete before executing the preoperational test. The staff requested that the applicant add this requirement as a test "Prerequisite" to the subject preoperational tests. Given the importance of this issue to plant safety, the staff went on to request that a line item be added to ITACC Table 2.7.5.4-3, “Auxiliary Building Ventilation System Inspections, Tests, Analyses, and Acceptance Criteria,” that seismic II/I construction is complete and that the DC II/I walk down is complete. The applicant agreed that a requirement for the completion of ITAAC related to seismic qualification of SSCs prior to fuel loading would be appropriate. Given the applicant’s concurrence that an ITAAC was appropriate, a preoperational test revision was not necessary. The staff found that the applicant failed to amend the DCD (Revision 2) with what it agreed would be appropriate. The staff submitted follow-up RAI 558-4227, Question 06.05.01-17. In RAI 558-4227, Question 06.05.01-17 the staff noted that the staff could find no evidence in the Tier 1 ITAAC that Seismic II/I walkdowns of non-seismic/nonsafety related systems are required and are to be completed prior to fuel load.

The applicant responded in a letter dated May 27, 2010 (ML101530606), with a proposed revision to the DCD by adding an ITAAC to Tier 1 Table 2.7.5.4-3 for the ABVS. The applicant also agreed to amend Tier 1 Subsection 2.7.5.4.1.1 and Tier 2 DCD Subsection 9.4.3.1 to provide a comprehensive resolution. These amendments, when incorporated into the DCD, would resolve the staff’s documented concern for the ABVS and the staff found the applicant’s approach acceptable.

The staff verified that DCD Revision 3 Tier 2 Subsections 9.4.3.1, 9.4.6.2.1, 9.4.6.2.2, 9.4.6.2.3, 9.4.6.2.4.1 and 9.4.6.2.4.2 contained the applicant’s described changes in response to RAI 558-4227, Question 06.05.01-17. Also as a result of this revision, Tier 1 Table 2.7.5.4-3, “Auxiliary Building Ventilation System Inspections, Tests, Analyses, and Acceptance Criteria,” now contains Item 11 which will ensure that the non-safety related portions of the as-built ABVS will be analyzed and inspected against Seismic Category II requirements. The staff finds this change of approach acceptable since Item 11 provides a method to ensure GDC 2 compliance. Based on this, the staff **closed RAI 68-841, Question 09.04.03-1, and RAI 558-4227, Question 06.05.01-17.**

DCD Section 9.4.3.1.1.3, indicates that the main steam/feedwater piping area HVAC system is neither safety-related nor Seismic Category I. However, appropriate supports for the system ductwork prevent adverse interaction with other safety-related systems during a seismic event. Figure 9.4.3-1 appears to show ABVS ducting that continues into safety-related areas such as the Safety-Related Component area shown on Figure 9.4.5-5. Additionally the staff noted that there is no specific reference to RG 1.29 Positions C.1 and C.2 in DCD Section 9.4.3. The staff in RAI 68-841, Question 09.04.03-1, requested additional information from the applicant to clarify compliance with RG 1.29 and if there are additional locations where ductwork will have to be supported to prevent adverse interactions with safety-related equipment. In addition, the staff asked the applicant to provide additional references in the appropriate sections of the DCD to address seismic design and clarify other inconsistencies in the FSAR.

In its response dated October 08, 2008 (ML082840131), to RAI 68-841, Question 9.4.3-1, the applicant stated that the main steam/feedwater piping area houses the main steam/feedwater piping HVAC system. The ductwork will drop down and be routed in the piping area as required. Main steam/feedwater piping is safety-related and Seismic Category I. Therefore, this ductwork would require RG 1.29, Item C2 compliance. The applicant agreed to include statements, regarding suspended ductworks, describing its characteristics and potential impacts regarding other systems in the revision of the DCD. The applicant also agreed to include a more descriptive statement in all HVAC system sections of the DCD (including Section 9.4.3) where conditions are known to apply or expected regarding ductwork attached to safety-related Seismic Category I isolation dampers to clearly denote seismic requirements (per required RGs, Codes, etc.) of the ductwork. The applicant agreed to include a statement in the appropriate DCD section(s) denoting the AB HVAC system ductwork is designed to non-seismic and Seismic Category II. The ductwork is designed to Seismic Category II requirements in the Fuel Pool Handling area, in the RB and in the PSB if the ductwork is routed in the area housing safety-related SSCs. The staff found the applicant's approach acceptable. The staff confirmed that the applicant revised the DCD. The staff found the response and the revisions to the DCD acceptable and **closed RAI 68-841, Question 09.04.03-1, Part 5.**

In RAI 68-841, Question 09.04.03-1, Part 11 the staff requested that the applicant amend Table 3.2-2 to eliminate conflicting statements regarding the existence of Class 2 and Class 3 Seismic I Isolation Dampers.

The applicant responded on October 08, 2008 (ML082840131), with an amended system description for DCD Subsection 9.4.3.2.1 which indicates that penetration and safeguard component areas supply and exhaust line isolation damper assemblies are Equipment Class 2, Seismic Category I and an amendment to Table 3.2-2 that removed the DCD conflicts. The staff verified that DCD Revision 3 included the above description and the amendment to Table 3.2-2 that removed the subject conflicts. Based on this, the staff found the response acceptable and **closed RAI 68-841, Question 09.04.03-1, Part 11.**

Based on the staff's review of Revision 3 of the DCD, the foregoing RAI exchanges and DCD enhancements, the staff concluded that the ABVS as described in the US-APWR DCD satisfies the requirements of GDC 2.

9.4.3.4.2 General Design Criterion 5

The staff reviewed the design of the ABVS to ensure that it meets the relevant requirements of GDC 5. GDC 5 requires that SSCs important to safety shall not be shared among nuclear power units unless it can be shown that such sharing will not significantly impair their ability to perform safety functions. Since this application is for a single unit - ++plant and the ABVS has no provisions for sharing SSCs between multiple units, the staff found that the requirements of GDC 5 do not apply to this system.

9.4.3.4.3 General Design Criterion 60

The staff reviewed the ABVS to ensure it meets the relevant requirements of 10 CFR 50 Appendix A GDC 60 as related to the capability of the system to suitably control release of gaseous radioactive effluents to the environment. The staff reviewed the ABVS to ensure that the system is capable of suitably controlling release of gaseous radioactive effluents to the environment by meeting the applicable guidelines of RG 1.140.

The staff requested in RAI 68-841, Question 09.04.03-1, Part 4 that the applicant provide additional information and to clarify why the Annulus Emergency Exhaust Filtration Unit Areas and the Charging Pump Areas do not switch over to be exhausted through the Annulus Emergency Exhaust Filtration Units. In addition, the staff asked why there is no double isolation between these two controlled areas and the rest of the uncontrolled AB. Specifically, the staff was concerned that the charging pump areas could contain radioactive material. The staff issued numerous questions and follow-up questions attempting to define the intended functions of the system.

After a number of submittals and RAIs were exchanged, the applicant responded in a letter dated February 05, 2010 (ML100480086), that although the CVCS, including the charging pump areas, does not contain highly radioactive fluids during normal operation and that the design includes the consideration that these system areas may become contaminated during and post accident events. This design approach is consistent with the findings in NUREG-0737, "Clarification of TMI Action Plan Requirements," and NUREG-0578, "TMI-2 Lessons Learned Task Force Status Report and Short Term Recommendations," which include the CVCS in the systems outside containment that may potentially contain highly radioactive fluid. To ensure that there are adequate controls on the release of radioactive materials in gaseous effluents, provisions such as radiation monitors are included in the AB HVAC System design.

Figure 9.4.3-1, "Auxiliary Building HVAC System Flow Diagram" in Revision 2 of the DCD shows the merging in one duct of the AB Charging Pump Areas and the AB Annulus Emergency Exhaust Filtration Unit Areas within the controlled area of the RB. The air-flow in this duct is monitored by radiation monitor RE-48A to determine if high levels of radioactivity are present. Under normal operating conditions, when high levels of radioactive material are not present, the airflow is routed through the normally open, air operated damper (VAS-AOD-372-N) to the AB Exhaust Fans and then to the vent stack for release. Upon detection of high levels of radioactivity in this duct exiting the controlled area of the RB, the normally closed, air operated damper (VAS-AOD-373-N) is opened and the normally open damper (VAS-AOD-372-N) is closed. The airflow in the duct is then routed to connect with the duct to the Containment Low Volume Purge Exhaust Filtration Units, as shown on Figure 9.4.3-1, which will pass the radioactive exhaust air through a HEPA filter as well as through charcoal absorber filters. This filter arrangement will effectively remove the majority of radioactive materials from the exhaust air stream before it is sent to the vent stack for release. The vent stack also contains radiation monitors that are used during all modes of operation to provide assurance that the release of radioactive materials contained in gaseous effluents will not exceed the limits specified in 10 CFR Part 20.

This arrangement, which allows the radiological controlled areas of the AB and RB to be filtered by the containment low volume purge exhaust filtration units, meets the requirements of 10 CFR 50 Appendix A GDC 60.

The applicant concluded its response with a discussion of the areas of conflicting information as noted in the staff's RAI question. The applicant clarified EQ statements and which components of the CVCS system are listed on which pages/tables of the DCD. The applicant also clarified the design basis source term for the CVCS, which includes the one percent fuel defects for shielding and the normal operating source term per ANSI/ANS-18.1. This will also control and limit continued operation under one percent failed fuel to prevent excessive contamination and high exposures and costly cleanups.

The applicant proposed to add a paragraph to Section 9.4.3.2.1, in DCD Revision 2 that captures the clarifying language from the response. With the exception of the two items noted below the staff found the applicant's response acceptable. To address the exceptions, the staff submitted in sequence RAI 4845, Question 09.04.03-11 (ML102920331) and RAI 5865, Question 09.04.03-14 (ML11227A045).

In RAI 634-4845, Question 09.04.03-11 and follow-up RAI 779-5865, Question 09.04.03-14, the staff asked about the prevention of back flow of containment purge ventilation air into areas of the fuel handling area building RB, AB and AC/B controlled areas, and requested that the applicant provide additional clarification regarding the sequence for the containment low volume purge system shutdown and isolation when exhaust from the AB HVAC system is filtered by the containment low volume purge exhaust filtration unit. The applicant responded with an amendment to the last sentence of the eighth paragraph of DCD Subsection 9.4.6.2.4.1, which clarified the function and alignment of the system.

The staff found the applicant's response acceptable since it sets in place in the DCD, the prevention of back flow of purge ventilation air from the Containment into unintended areas served by the ABVS. This **staff tracks Part "1" of RAI 779-5865, Question 09.04.03-14, as Confirmatory Item 09.04.03-14,** pending the revision of Subsection 9.4.6.2.4.1.

In the second part of RAI 634-4845, Question 09.04.03-11, the staff asked about occupational radiation protection. In particular, the staff found the applicant's response to Part 3 of RAI 483-3885, Question 09.04.03-9 to be in conflict with the acceptance criteria of SRP 12.2 and the acceptance criteria 3 and 4.B of SRP 12.3-12.4. In its response dated February 05, 2010, the applicant acknowledged that the response to RAI 483-3885, Question 09.04.03-9, Part 3, incorrectly implied that the ANSI/ANS-18.1 source term was utilized for in plant airborne activity levels. The applicant discussed two source terms consistent with the guidance in RG 1.206 Section C.1.11.1: a design basis source term and a realistic source term.

The staff found the applicant's response acceptable since it clarified the point of confusion associated with the applicant's previous response to RAI 483-3885, Question 09.04.03-9. Based on this, the staff closed the second part of RAI 779-5865, Question 09.04.03-14.

In summary, the staff tracks **as a confirmatory item** one of the issues associated with the RAI sequence: **RAI 68-841, Question 09.04.03-1, Part 4; RAI 355-2492, Question 09.04.03-2; RAI 483-3885 Question 09.04.03-9; RAI 4845, Question 09.04.03-11; and RAI 5865, Question 09.04.03-14, Confirmatory Item 09.04.03-14.**

Further with regard to GDC 60 compliance, the staff asked a two-part question in RAI 68-841, Question 09.04.03-1, Part-8, (ML082840131). In the first part, the staff noted that DCD Table 9.4.3-1, "Equipment Design Data," did not list all of the components in the AHUs shown in DCD Figures 9.4.3-1, 9.4.3-2, 9.4.3-3, and 9.4.3-4. The applicant responded by providing a list of the missing components with the corresponding filter efficiencies and a proposed revision to DCD Table 9.4.3-1 to include information for all of the components in the AHUs as shown in DCD Figures 9.4.3-1, 9.4.3-2, 9.4.3-3, and 9.4.3-4. The staff confirmed that the applicant revised the DCD to incorporate the changes described in the applicant's response. The staff found the applicant's response acceptable since the figures were revised to include the missing components. Based on this, the staff **closed the first part** of **RAI 68-841, Question 09.04.03-1, Part 8.**

In the second part of RAI 68-841, Question 09.04.03-1, Part 8, the staff requested that the applicant provide additional information on the exception to GDC 60 cited in DCD Table 1.9.2-9. For DCD Subsection 9.4.3 the Table's exception reads "Criterion 3: Air clean-up function is provided for TSC HVAC system only." The staff went on to note that RG 1.140, for normal atmosphere clean-up systems, Position C.3.1 states that typical systems should have HEPA filters and carbon adsorbers and goes on to state that whenever a normal atmosphere cleanup system is designed to remove only particulate matter, a component for iodine adsorption need not be included. DCD Section 9.4.3.1.2.1 states the AB HVAC system maintains dose levels due to airborne radioactivity below the allowable values set by 10 CFR 20 by supplying and exhausting sufficient air flow. The staff requested additional information or references to the appropriate DCD sections regarding how the AB HVAC systems with no HEPA filters or carbon adsorbers during normal operation and only HEPA filters, no carbon adsorbers, in the annulus emergency exhaust filtration unit during the ESF mode meets the limits specified in 10 CFR Part 20.

The applicant responded that the radiological controlled areas are ventilated by the AB HVAC system. The exhaust air from the radiological controlled areas is not filtered before release to the environment via the vent stack. During normal plant operation, the release of radioactive materials entrained in gaseous effluents does not exceed the limits specified in 10 CFR 20 as described in DCD Subsection 11.3.3.1. The AB HVAC system is not used in postulated accidents. During the postulated accidents, the annulus emergency exhaust system is used to maintain a negative pressure in the penetration and safeguard component areas relative to adjacent areas and the exhaust air from the penetration and safeguard component areas is filtered by only HEPA filters before release to the environment via the vent stack. Chapter 15, Subsection 15.6.5, analyzes the DBA LOCA. The EAB and LPZ doses are shown to meet the 10 CFR 50.34 dose guidelines. Chapter 15, Subsection 15.4.8 analyzes the DBA rod ejection accident. The resultant doses are well within the guideline limit of 25 rem identified in 10 CFR 50.34. Both analyses meet the criteria without carbon adsorbers. By virtue of monitoring airborne radiation in the exhaust duct, and providing an alarm to alert on high radiation, this function enables the system to comply with GDC 60 requirements; this system does not incorporate the cleanup system that complies with RG 1.52 or RG 1.140. Therefore, the applicant concluded the AB HVAC system is not required to meet GDC 60.

The staff found the applicant's response dated October 08, 2008, incomplete. In the response to RAI 68-841, Question 09.04.03-1, Part 8 the applicant invoked a passage from SRP 9.4.3, Technical Rational, 3 which states: "Meeting these (i.e. GDC 60) requirements provides assurance that release of radioactive materials entrained in gaseous effluents will not exceed the limits specified in 10 CFR Part 20 for normal operation and anticipated operational occurrences." From this passage, the applicant concluded, "*Therefore, MHI believes that the annulus emergency exhaust system is not required to meet the 10 CFR 20.*" The two accidents cited by the applicant as the basis for this conclusion were the "postulated accidents" of "Fuel Handling Accident" and "Spectrum of Rod Ejection Accidents." For these "postulated accidents" the guideline limit of 25 rem identified in 10 CFR 50.34 governs.

The staff noted that to invoke the limitations of 10 CFR 20 with respect to a "postulated accident" in the applicant's conclusion is not consistent with the requirements. It appears that the applicant did not consider AOOs and their impact on plant personnel access inside the plant in its response to RAI 68-841, Question 09.04.03-1, Part 8. The staff requested that the applicant demonstrate the system performs adequately for the design basis AAO. The applicant had not identified the design basis AAO. Based on the requirements of SRP 9.4.3 Technical Rational 1 & 3, the staff requested that the applicant redress its response to RAI 68-841, Question 09.04.03-1, Part 8 and issued a follow-up **RAI 355-2492, Question 09.04.03-3**.

The applicant responded in a letter dated October 15, 2010, that within the AB, areas with higher potential airborne radioactivity levels, such as pump rooms, are provided with individual branch ducts from the main supply and exhaust ducts as shown in DCD Figure 9.4.3-1, or are provided with transferred air from the areas with lower potential airborne radioactivity levels (e.g. corridors, passages) and individual branch ducts from the main exhaust duct. As indicated in DCD Subsection 9.4.3.2.1, these branch ducts include a balancing damper that is used to balance ventilation flowrate to ensure adequate exhaust from the higher radioactivity areas such that airflow is from low to high radioactivity areas.

The main steam/feedwater piping area is within the RB uncontrolled area. As described in DCD Subsection 9.4.3, the main steam/feedwater piping area HVAC system provides heating and cooling ventilation for this area. As shown in DCD Figure 9.4.3-1, the AB HVAC system provides supply and exhaust ventilation for the general RB uncontrolled areas. The AB HVAC system maintains a slightly negative pressure in the adjacent RB uncontrolled areas such that airflow is from the main steam/feedwater piping area, minimizing the potential for infiltration of airborne radioactive contaminants. Similarly for other uncontrolled areas, the AB HVAC system is designed to maintain airflow from areas of low radioactivity to areas of potentially higher radioactivity as stated in DCD Subsection 9.4.3.1.2.1.

In addition, backdraft dampers are provided in the ventilation duct exhausting uncontrolled areas to prevent backflow from the AB HVAC system. The backdraft dampers are also provided in the supply duct to uncontrolled areas to prevent backflow when the AB HVAC system is stopped. DCD Subsection 9.4.3.2.1 will be revised to indicate that backdraft dampers are installed in supply lines to uncontrolled areas and exhaust lines from uncontrolled areas.

The staff reviewed the applicant’s response of October 15, 2010, and found it acceptable in that it adequately explained how maintaining ventilation flows from areas of low radioactivity to areas of potentially high radioactivity would be achieved. The applicant proposed a revision to DCD Subsection 9.4.3.2.1 with words about the presence of system backdraft dampers. **This is Confirmatory Item, 09.04.03-3.** However, the staff notes that Figure 1.7.4 “Legend for Piping and Instrumentation Diagrams of HVAC System” contains a symbol for backdraft dampers. Therefore, the staff believes that the backdraft dampers should be displayed in Figure 9.4.3-1 “Auxiliary Building HVAC System Flow Diagram” since these dampers perform a necessary contamination control function. **This is Open Item 09.04.03-21** *(see Follow-up RAI below)***.**

Based on the foregoing, the staff holds both **Confirmatory Item** and **Open Item** for an issue in the RAI series: **RAI 355-2492, Question 09.04.03-3; RAI 483-3885, Question 09.04.03-10; RAI 634-4845, Question 09.04.03-12; RAI 779-5865, Question 09.04.03-15**. The staff issued **RAI 6030, Question 09.04.03-21, Open Item 09.04.03-21** requesting that the applicant amend DCD Figure 9.4.3-1 to reflect the existence of backdraft dampers.

During the review of interfacing systems, the staff identified a potential issue with GDC 60 and 10 CFR Part 20 for the GWMS. The staff noted that DCD Section 11.3.1.4 for the GWMS reads, “ …to dilute this gas further, it is mixed with the A/B ventilation flow before it is discharged to the environment.” DCD Section 11.3.1.4 goes on to state that the design of the GWMS limits releases of radioactive gases below the concentration limits of 10 CFR 20. The HVAC ventilation flow provides dilution for the GWMS release in the vent stack and discharge isolation valves close on low ventilation system exhaust flow rate. The staff went on to note that DCD Section 11.3.4 also states that the ventilation system is designed in accordance with RG 1.140 and is described in Chapter 9, Section 9.4. The staff found no reference to or description of the GWMS and its interface points with the AB ventilation system in DCD Sections 9.4 or 9.4.3. The staff noted that this system interface should also be identified as an attribute in Tier 1 Section 2.7.5.4, “Auxiliary Building Ventilation System.” In RAI 68-841, Question 09.04.03-1, Part 9, the staff requested that the applicant provide additional information and clarification in DCD Section 9.4.3 and Tier 1 Section 2.7.5.4 regarding where and how the GWMS interfaces with the ABVS.

The applicant responded in a letter dated October 08, 2008 (ML082840131), that it would add the system interface with the GWMS and revise the description to provide the consistency between the AB HVAC system and the GWMS. The staff confirmed that the applicant amended Subsection 9.4.3.2.1 of the DCD to reflect the ABVS interface with the GWMS.

With respect to the staff's request for clarification regarding the addition of the GWMS dilution function to Tier 1, the staff found that the applicant's response was incomplete. More RAIs were exchanged concerning the need for Tier 1 inclusion of this dilution function. Based on this, the staff holds this issue as an **Open Item -- RAI 68-841, Question 09.04.03-1, Part 9; RAI 355-2492 Question 09.04.03-4.** The staff issued **RAI 6030, Question 09.04.03-17, Open Item 09.04.03-17** to request additional justification for not including in Tier 1 the ABVS dilution function in support of the GWMS.

GDC 60 requires provisions be included in the design to ensure suitable controls on the release of radioactive materials in gaseous effluents during normal reactor operation, including AOOs. The staff noted that DCD Section 9.4.3.1.2.1 contains the following three design bases: (1) Keep dose levels due to the airborne radioactivity below the allowable values set by 10 CFR 20 by supplying and exhausting sufficient airflow; (2) Control exhaust fan airflow continuously and automatically at a predetermined value to maintain a slightly negative pressure in the controlled areas relative to the outside atmosphere and minimize exfiltration from the radiological controlled areas during normal plant operation; and (3) Maintain airflow from areas of low radioactivity to areas of potentially higher radioactivity. The staff noted that there was not enough design information to demonstrate the functions could be accomplished. In addition the staff noted that there was nothing in Preoperational Test 14.2.12.1.99. "Auxiliary Building HVAC System Preoperational Test" or in Tier 1 Section 2.7.5.4.1.1 and Table 2.7.5.4-2 that specifically required that the COL applicant satisfy the three design bases above and "provide and maintain proper operating environment within the required temperature range (Table 9.4-1) for areas housing mechanical and electrical equipment within the AB, RB, PSB and AC/B during normal plant operation.

The staff and applicant had a series of RAI exchanges to address these issues as captured in RAI 68-841, Question 09.04.03-1, Part 13, dated October 8, 2008 (ML082840131), RAI 355-2492, Question 09.04.03-5 dated July 17, 2009 (ML092030376), and RAI 483-3885, Question 09.04.05-8 dated February 5, 2010 (ML100480086).

The staff found the applicant's answers acceptable with some exceptions. In particular, the staff noted that no ITAAC were present for verifying that an unmonitored release will not occur under credible worst case ventilation balance conditions. The staff requested that the applicant provide an engineering solution that addresses the worst case ventilation balance. The staff noted that the applicant did not identify any methods or process controls that prevent an unmonitored release through the TB.

The applicant concluded its response to Parts I and II of RAI 483-3885, Question 09.04.03-08 with a proposed addition of two new ITAAC line items (i.e. #9 & #10) to Tier 1 Table 2.7.5.4-3. In particular, the applicant proposed to add an ITAAC item to Table 2.7.5.4-3 to verify through tests and analysis that the ABVS can maintain the proper environmental conditions during normal operation. In addition, the applicant proposed to add an ITAAC to verify the flow rate of the ventilation system to create a slightly negative pressure during normal operation in the controlled areas.

After reviewing the applicant’s response to RAI 483-3885, Question 09.04.03-08 Parts I and II, dated February 05, 2010, the staff had requested further clarification in RAI 634-4845, Question 09.04.03-13 dated October 15, 2010 (ML102920331), and RAI 779-5865, Question 09.04.03-16 dated August 11, 2011 (ML11227A045), regarding the systems abilabity to maintain a negative pressure and about automatic controls to maintain needed flow rates.

The applicant responded on August 11, 2011, stating that during normal operation, the AB HVAC system exhaust contains insignificant amounts of radioactive material and is discharged to the atmosphere without filtration, via the plant vent. During normal operating conditions, exfiltration of minimal amounts of this air is expected and represents no significant increase in occupational exposure or offsite dose. The ABVS is also designed to maintain a "slight negative pressure" in the areas it services. This negative pressure "minimizes," but does not prevent, exfiltration from radiological controlled areas during normal plant operation. Minimization of exfiltration is accomplished by maintaining AB HVAC system exhaust flow at a consistently higher flow rate than supply flow. The applicant did propose to amend the Acceptance Criteria to ITAAC Table 2.7.5.4-3 to address flow rates and maintaining negative pressure.

The staff noted that the applicant’s response implies that an unmonitored release (i.e. exfiltration) from the areas served by the ABVS is acceptable based on the fact that the plant emits insignificant amounts of radioactive material through the plant stack during normal operations. **The staff concludes that Part 1 of RAI 634-4845, Question 09.04.03-13 remains an open item.** The staff issued follow-up **RAI 6030, Question 09.04.03-18, Open Item 09.04.03-18** to obtain clarification regarding the acceptance criteria in the proposed ITAAC.

In Part 2 of RAI 634-4845, Question 09.04.03-13, the staff noted that the prevention of flow from controlled areas of the AB to other adjacent clean areas/buildings was not adequately addressed in RAI 483-3885, Question 09.04.03-08. The clean areas in adjacent buildings must be maintained at a higher pressure than the areas served by the ABVS to prevent an unmonitored release. The staff requested that the applicant amend Section 14.2.12.1.99 “Auxiliary Building HVAC System Pre-operational Test,” to include this requirement as part of the test method and acceptance criteria.

The applicant responded on October 15, 2011, with a proposed revision of preoperational test 14.2.12.1.99 and Subsection 9.4.3.4.1 with concise words that address the staff’s principal concern identified in RAI 634-4845, Question 09.04.03-13. The applicant stated that determination of the required frequency of periodic confirmation of flow balance is the responsibility of the COL applicant. The staff verified that Revision 3 of the DCD contained both described changes. Beyond these issues, the staff had one residual concern as documented in RAI 779-5865, Question No. 09.04.03-16, which pertained to the design of the interface connection from the common discharge line of the low volume containment purge system (LVCP) and of the high volume containment purge system (HVCP) to the ABVS discharge line. This interface connection is displayed in Figure 9.4.3-1 as being downstream of the three AB Exhaust Fans and upstream of air-operated dampers VAS-AOD-511-S and VAS-AOD-512-S. The staff asked several detailed questions regarding this interface, but the principal concern of the questions had to do with the potential for backflow from the containment purge process into the areas served by the ABVS.

In addition, the staff noted that the applicant's response dated October 15, 2010, to Part 2 of RAI 634-4845, Question 09.04.03-13 included the words "backdraft dampers installed at penetrations between controlled and clean areas prevent ventilation backflow from potentially contaminated areas." The staff noted that Figure 9.4.3-1 does not display these backdraft dampers and DCD Section 9.4.3 "Auxiliary Building Ventilation System" does not discuss the existence of the dampers. The staff requested that the applicant revise both DCD Section 9.4.3 and Figure 9.4.3-1 to include a discussion and representation of these backdraft dampers.

The applicant responded on October 15, 2010, with a proposed revision to add flow damper VAS-AOD-513-N between the interface connection and the three AB Exhaust Fans. This flow damper will be installed to adjust the ABVS exhaust airflow rate to design flow rate described in DCD Subsection 9.4.3.2.1 regardless of the operation of HVCP and LVCP. HVCP does not operate under two psig containment pressure plus the pressure developed across the fan since HVCP operates during refueling operations. During the operation of LVCP under these conditions, the ABVS provides the design exhaust air by the adjustment of the flow damper VAS-AOD-513-N. Therefore, there is no airflow from HVCP and LVCP to ABVS under these conditions.

The applicant continued in its response that the connection from the ventilation containment system (VCS) low volume and high volume purge exhaust to the ABVS exhaust duct provides a flow path to the vent stack as shown on DCD Figure 9.4.3-1. The ductwork for this connection and the ABVS exhaust duct and the duct from individual areas in the AB to the VCS low volume purge exhaust filtration unit inlet is rated for pressure conditions resulting from the containment purge operation, including an initial containment pressure of two psig plus the pressure developed across the fans of HVCP and LVCP, since these ducts could be pressurized during purge operation. Airflow is from the VCS to the vent stack during purge operations, and the duct is sized for maximum system flow rate. There is no backflow to the AB from the VCS because ABVS exhaust fan discharge isolation dampers are closed for non-operating fans. The high volume containment purge and low volume containment purge exhaust fans are interlocked with flow dampers VAS-AOD-511-S and VAS-AOD-512-S such that the fans will not start if the dampers are closed. Therefore, there is no potential for backflow to the ABVS from containment purge exhaust due to the closure of these flow dampers.

The applicant concluded its response that revision of DCD Subsection 9.4.3.2.1 to describe the backdraft dampers will take place consistent with the response to RAI 779-5865, Question 09.04.03-15. The applicant closed its response by indicating that this level of detail (i.e. display of backdraft dampers) is not shown in the simplified flow diagram in DCD Figure 9.4.3-1.

The staff found the applicant's response acceptable since the installation of flow damper VAS-AOD-513-N will prevent backflow from containment purging operations into areas served by the ABVS. However, the staff notes that the technical details of the applicant's response need to be added to the DCD. In addition, the responsibility for establishing an appropriate frequency of checking the flow balance to prevent an unmonitored release needs to be clearly assigned to the COL applicant in the DCD. Based on this, the **staff holds Part 2 of RAI 634-4845, Question 09.04.03-13 as an open item.** The staff issued follow-up **RAI 6030, Question 09.04.03-19, Open Item 09.04.03-19** to request an update to the DCD to address these issues.

In Part 5 of RAI 634-4845, Question 09.04.03-13, the staff submitted a follow-up question to RAI 483-3885, Question 09.04.03-8. The staff again asked about the potential flow from a potentially contaminated area to an unmonitored area due to a pressure differential between the TB (which has its own ventilation system) and the AB through the interconnection of the two buildings via the non-radiological sump drain system as noted on Figure 9.3.3-1. The staff requested that the applicant provide an engineering solution to this potential path for an unmonitored release.

The applicant responded on February 05, 2010, that, as described in DCD Subsection 9.3.3.1.2, the non-radioactive floor and equipment drains in the non-radioactive drain sump collected by the TB drain system is sent to the waste water system. In the unlikely event that the TB sump contents become radioactive, the operator can open the normally closed valve to pump the contents to the AB sump. The valve would only be opened during pumping, at which time pump discharge pressure would prevent air flow from the AB to the TB.

The staff further inquired about the existence of check valves in the sump lines and the existence of administrative controls for the normally closed valve that would prevent backflow from the AB to the TB through this sump pathway. The applicant responded that there are check valves in the sump lines that would prevent backflow from the AB to the TB through this sump pump discharge pathway. Therefore, there would not be airflow from the AB to the TB through the interconnection via the non-radiological sump drain system. This level of detail is not shown in the simplified flow diagram in DCD Figure 9.3.3-1. No specific administrative controls are provided for the normally closed valve in the sump pump discharge line that isolates the TB sump from the AB sump.

The staff could find no mention of check valves in Revision 3 DCD Section 9.3.3 “Equipment and Floor Drainage Systems” and their role in preventing an unmonitored release. The staff believes that such a description is warranted in Section 9.3.3 to ensure that check valves are installed where appropriate to prevent unmonitored releases. In addition, Figure 9.3.3-1 labels the valve from the TB sump discharge to the AB Waste Holdup Tank as failed closed (i.e. “FC”). The staff believes that changing the valve’s designation as a locked close (i.e. “LC”) valve would ensure the desired administrative controls needed to prevent an unmonitored release. Based on these needed changes to the DCD, **the staff holds Part 5 of RAI 634-4845, Question 09.04.03-13 as an open item.** The staff issued follow-up **RAI 6030, Question 09.04.03-20, Open Item 09.04.03-20** to prompt additional remedies to the above noted staff concerns.

Based on the foregoing issues the staff holds as an **Open Item – the series RAI 68-841, Question 09.04.03-1, Part 13; RAI 355-2492, Question RAI 09.04.03-5(a)(b)(c)(d); RAI 483-3885, Question 09.04.03-08; RAI 4845, Question 09.04.03-13 and RAI 779-5865, Question 09.04.03-16, with three follow-up RAI questions: RAI 6030, Question 09.04.03-18, Open Item 09.04.03-18, Question 09.04.03-19 , Open Item 09.04.03-19 and Question 09.04.03-20, Open Item 09.04.03-20.**

9.4.3.4.4 Duct Heaters Issue

SRP 9.4.3 directs the reviewer to ensure that the P&IDs show the equipment used and the divisions between essential and nonessential portions of the system. The staff found that Figure 9.4.3-1 did not display thermostatically controlled temperature control valves providing non-essential chilled water to the AB AHUs. The staff also found that Table 9.4.3-1 “Equipment Design Data” did not reflect the site-specific existence of area heaters. The staff requested that the applicant amend the FSAR and all figures for the ABVS (i.e. Figures 9.4.3-1 through 9.4.3-4) to display this system attribute.

The applicant response consisted of two parts dated October 08, 2008 (ML082840131), and dated July 17, 2009 (ML092030376). The applicant provided a revision to Figure 9.4.3-1 through 9.4.3-4 to display the non-essential chilled water system interface. The applicant also proposed to add flow diagrams of the non-essential chilled water in DCD Subsection 9.2.7 (See, RAI 68-841, Question 9.4.3-12). The applicant invoked RG 1.206, C.1.9.4.3.2 "System Description" which states: “The system description should include the system major components, key parameters, essential controls, and operating mode.” Furthermore, with regard to the in-duct heaters, they are nonsafety-related equipment, are locally installed, and are not a major component. Hence, describing the subject in-duct heaters in the DCD is not required.

The applicant did provide a revision to the seventh paragraph of DCD Section 9.4.3.2.1 to describe clearly that the in-duct heaters are only nonsafety-related and located locally. The applicant’s response clarified that the nonsafety-related in-duct heaters are not considered major components and that COL Information Item 9.4(4) is for cooling and heating coils that are major components. Based on the technical detail added with the changes to DCD Figure 9.4.3-1 through 9.4.3-4, DCD Subsection 9.2.7 and DCD Subsection 9.4.3.2.1, the staff found the applicant’s response acceptable. The staff confirmed that the changes described in the applicant’s response have been incorporated in the DCD and **closed both RAI 68-841, Question 09.04.03-1, Part 14 and RAI 355-2492, Question 09-04.03-6.**

9.4.3.4.5 Electrical Interfaces/Interfacing Components

SRP 9.4.3 Section I requires a review to determine the adequacy of the design, installation, inspection, and testing of all essential electrical components (sensing, control, and power) required for proper operation. The staff noted that the first bullet of DCD Section 9.4.3.1.2.3 states a requirement for the main steam/feedwater piping area HVAC system to provide and maintain proper environmental conditions within the required temperature range (Table 9.4-1) suitable to support the operation and provide assurance of the electrical and mechanical components reliability. The staff also noted that DCD Section 9.4.3.1.1.3 states that there are no safety design bases for the main steam/feedwater piping area HVAC system. However, required ductwork will be supported to prevent adverse interaction with other safety-related systems during a seismic event. This passage indicates that safety-related electrical and mechanical components may be located within the main steam/feedwater piping areas cooled by the main steam/feedwater piping area HVAC system as displayed in DCD Figure 9.4.3-3. The staff requested in RAI 68-841, Question 09.04.03-1, Part 18 that the applicant provide additional information and clarification on the function of the HVAC systems in relation to the safety-related equipment.

In its response on October 8, 2008 (ML082840131), the applicant stated that the main steam/feedwater piping area houses the main steam/feedwater piping HVAC system. The ductwork will drop down into and be routed in the piping area as required. The applicant stated that the main steam/feedwater piping in the piping area is safety-related and Seismic Category I. Therefore, this HVAC system's ductwork, or portions thereof routed over safety-related equipment, should be designed to Seismic Category II requirements. The applicant responded that it is not necessary to detail what safety-related electrical and mechanical components are located in this area. It is sufficient to say there is safety-related equipment in the area and any ductwork located over this equipment shall be seismically (Category II) supported. The main steam / feed water piping is not active during a LOOP or other abnormal condition. Therefore, during these abnormal events the nonessential chilled water system does not provide cooling in the piping area. This system is nonsafety-related and does not need to operate during an event. Therefore, this system has no electrical power and is inoperable during a LOOP or other abnormal event. These values will be discussed in Technical Report, "US-APWR Equipment Environmental Qualification Program." These AHUs will be designed to preclude internally generated missiles from the AHU fans if safety-related components are located within the vicinity of the two AHUs. The applicant revised DCD Sections 9.4.3.2.3, 9.4.3.1.1.3 and Table 3.2-2 to address the support of non-safety related equipment and ductwork within areas containing safety-related equipment (Seismic Category II). The staff found the responses for the first four issues acceptable.

The staff noted that the applicant in its response indicated that the AHUs would be designed to preclude internally generated missiles from the AHU fans if safety-related components are located within the vicinity of the two AHUs. However, the applicant did not commit to revising the DCD to include this requirement. Based on this lack of closure, the staff issued a follow-up closed RAI 355-2492, Question 09.04.03-7.

The applicant's response of July 17, 2009 (ML092030376), included adding a description of the main steam/feed-water piping area HVAC system AHUs housings that are resistant to penetration of internally generated missiles. The staff found that the applicant's response resolved its concern and was acceptable. The staff confirmed that the DCD was revised to incorporate the concise changes described in the applicant's response and **closed both RAI 68-841, Question 09.04.03-1, Part 18 and RAI 355-2492 Revision 1 Question 09.04.03-7**.

9.4.3.4.6 Technical Support Center HVAC System

SRP Section 13.3 "Emergency Planning" Section IV.4 "Standard Design Certification" addresses the TSC requirements including its general description, size and habitability. In RAI 68-841, Question 09.04.03-1, Part 19 the staff requested that the applicant describe the TSC ventilation system design, in sufficient detail (i.e. a calculation summary), to demonstrate the ventilation system ensures TSC habitability. The staff also asked about the level of staffing and TSC size, which could be site specific. Both of these variables could affect the sizing of ventilation components that comprise the TSC HVAC system. Due to these site-specific variables, the staff in RAI 68-841, Question 09.04.03-1, Part 19 recommended that the applicant create a COL item that captures the impact of these variables. The staff noted that implicit within the Regulatory Position 2.6 "Habitability" in NUREG-0696 is that the TSC would be subject to the same habitability testing requirements as the MCRE. DCD Section 9.4.3.4 "Inspection and Testing Requirements" does not reflect these testing requirements. The staff recommended that the applicant amend Section 9.4.3.4 to capture these testing requirements.

In its response dated October 08, 2008 (ML082840131), the applicant proposed to revise as required all TSC HVAC system subsection descriptions to clarify compliance with these requirements; and to include any additional system configuration, operational, testing and inspection criteria and design information where applicable. In addition, the applicant clarified that the TSC dose calculation models are discussed in DCD Subsection 15.6.5.5.1.3 and the input parameters used in the analysis are shown in RAI 38, Question 15.00.03-17 (ML082390259). For the issue of the staff's recommendation to add a COL action item to DCD Section 9.4.7, the applicant responded that DCD Subsection 13.3 states: "Interfaces of these features with site-specific designs and site parameters are the responsibility of the COL Applicant." If the design parameters (i.e. level of staffing, size of TSC) are changed, the impact of the change will be addressed in COLA Subsection 13.3 and a COL item in DCD Subsection

9.4.7 is not required. The staff found the applicant's response concerning the COL item request acceptable. The staff confirmed that the applicant revised the DCD to address TSC HVAC system requirements. The staff found the response acceptable and **closed RAI 68-841, Question 09.04.03-1, Part 19.**

9.4.3.4.7 Fire Protection Interfaces

10 CFR 50.48, Fire Protection, and associated NRC RG 1.189, Revision 1 address preventing smoke from migrating from one fire area to another so that safe shutdown capability is not adversely affected. In its review of the DCD, the staff found the following relevant to fire detection and ventilation system response: First - DCD Section 9.4.3.2.1, the last paragraph reads, "Smoke detectors located in the supply and exhaust air ducts detect the presence of smoke and activate an alarm in the MCR. If the smoke is detected in the supply or exhaust ducts, the auxiliary building HVAC system is manually shut down." Second - DCD Section 9.5.1.2.7 reads, "Ventilation system fire dampers close automatically against full airflow, if required, on high temperature to limit the spread of fire and combustion products. Fire dampers serving certain safety-related, smoke-sensitive areas are also closed in response to an initiation signal from the fire detection system. In selected areas, the fire alarm system will provide interface with the HVAC systems such as to shut down HVAC operation upon a fire alarm signal. Where continued HVAC system operation is deemed necessary for radiological control, the HVAC system incorporates design features to allow operation under fire conditions." DCD Section 9.4.3 does not indicate the fire protection attributes (e.g. fire dampers) installed in the ductwork for the areas served (i.e. Figure 9.4.3-1) by the AB HVAC system. This system interface with the fire protection system is fundamental to plant operations in its response to instances of smoke or fire within the areas served by the AB HVAC system. The staff requested in RAI 68-841, Question 09.04.03-1, Part 15 that the applicant amend DCD Section 9.4.3 to include information that reflects the existence of these fire protection system interfaces for the four subsystems that comprise the ABVS and the above passage from DCD Section 9.5.1.2.7.

The applicant revised DCD Section 9.4.3.2.1, 9.4.3.2.2, and 9.4.3.2.4, stating that the AB HVAC system contains ductwork that will penetrate fire barriers and that a rated fire damper is installed when a fire barrier is penetrated. The staff found these changes consistent with RG 1.189 and therefore acceptable. The staff **closed RAI 68-841, Question 09.04.03-1, Part 15.**

9.4.3.4.8 Technical Specifications

SRP 9.4.3 Section I addresses the review interface for the proposed TS. The staff noted that the AB HVAC system has the capability to close the safety-related, Seismic Category I isolation dampers of the penetration and safeguard component areas during a DBA and to close safety related, Seismic Category I isolation dampers to prevent back flow from the annulus emergency exhaust system during a DBA. The staff requested in RAI 68-841, Question 09.04.03-1, Part 16 that the applicant provide additional information as to how the TS of DCD Chapter 16 for the AB HVAC system test these functions of the safety-related isolation dampers.

The applicant responded in a letter dated October 08, 2008 (ML082840131), that operability testing of the AB HVAC supply and return dampers to the penetration and safeguard component areas is included in LCO 3.7.11, "Annulus Emergency Exhaust System." The applicant also clarified that the LCO 3.7.11 Bases section discusses the isolation feature for these dampers, initiated by an ECCS Actuation signal as well. The applicant stated testing of the dampers to actuate properly is conducted in SR 3.7.11.3 and testing that envelops integrity of the dampers to isolate the annulus exhaust system from the AB HVAC system is conducted in SR 3.7.11.4.

The applicant revised the DCD Subsection 9.4.3.4.1 to reference the TS SR for the annulus emergency exhaust system described in its response. The staff found the applicant's response to be acceptable, since it was comprehensive in scope and adequate in its remedy. Based on this, the staff **closed RAI 68-841, Question 09.04.03-1, Part 16**.

9.4.3.4.9 Industry Standards

As a part of satisfying the provisions of GDC 60, SRP 9.4.3 indicates that regulatory positions C.2 and C.3 of RG 1.140, Revision 2 should be used in the design, inspection, testing, and maintenance criteria for post-accident and normal atmosphere cleanup systems, ventilation exhaust systems, air filtration, and adsorption units of light water cooled nuclear power plants. SRP 9.4.3 Section III.1 states that the system review should demonstrate compliance with applicable industry standards including ASME AG-1.

The staff noted in its review of the DCD that Chapters 6 and 9 invoke AG-1-2003 directly or by reference in the following: Subsections 6.4.5, 6.5.1.5, 6.5.1.5.1, Table 6.4-2, and Tables 6.5-3, 9.4.1, 9.4.1.1.1, 9.4.1.4, 9.4.3.4.4, 9.4.5.1.1.1, 9.4.5.4.1, 9.4.6.4.4.1 and 9.4.6.4.4.2.

The standards employed in the design of the US-APWR were the subject of RAI 442-3378, Question 09.04.01-10. Specifically the staff questioned the use of a more recent version of ASME AG-1 than had been endorsed by the NRC staff. Revision 3 of RG 1.52 endorses ASME AG-1-1997 while the applicant's DCD referenced AG-1-2003 and AG-1a-2000. The applicant responded to RAI 442-3378, Question 09.04.01-10 with two RAI responses on September 18, 2009, and December 09, 2009, (ML092650173 and ML093480146) that made a comparison of the endorsed version versus the newer version. The results of the review were provided in a table. The applicant concluded that the use of the 2003 edition of the Code, rather than the 1997 edition referenced in the NRC guidance documents, is justified. The staff conducted an independent side-by-side comparison of the two AG-1 Codes to confirm that the use of ASME AG-1-2003 edition is an acceptable alternative to ASME AG-1-1997 for the MCR HVAC system design and testing. For the substantive areas of difference the applicant provided a comprehensive technical justification (as applicable) for the use of AG-1-2003 and AG-1a-2000, in lieu of AG-1-1997, in the design of the US-APWR DCD ventilation subsections. Based on this review, the staff concluded that the applicant had provided sufficient justification to demonstrate that the proposed alternatives to the SRP acceptance criteria provide acceptable methods of compliance with the NRC regulations. Based on this finding the staff **closed both RAI 442-3378, Question 9.4.1-10, and RAI 484-3850, Question 09.04.01-15**.

9.4.3.4.10 Documentation Inconsistencies

SRP 9.4.3 and GDC 60 establish requirements for the control of quantities of radioactive materials in gaseous effluents released to the environment from normal ventilation systems. The staff noted that consistent with SRP 9.4.3, the system description and P&IDs should identify essential safety-related portions of the ABVS and that these systems are isolable from nonessential portions of the system. The staff identified several inconsistencies in the system descriptions and P&IDs contained in the DCD. In particular, the staff noted the following inconsistencies:

- The diagram shown in Figure 9.4.3-1, "Auxiliary Building HVAC System Flow Diagram," includes the Fuel Handling Area, the AC/B Controlled Area, and the AC/B Uncontrolled Area. These areas were not included in the list in Section 9.4.3;

- The system description of Section 9.4.3.2 includes a reference to Figure 9.4.3-1 and Table 9.4.3-1. Table 9.4.3-1 did not include the equipment for the Fuel Handling Area, the AC/B Controlled Area or the AC/B Uncontrolled Area;

- Table 9.4-1 provides a list of areas supplied by the AB HVAC system. The list in Table 9.4-1 was not consistent with the systems listed on the diagram in Figure 9.4.3-1; and

- DCD Figure 9.4.3-3 "Main Steam/Feed water Piping Area HVAC System Flow Diagram" displayed the wrong system. It displayed the same system as shown on Figure 9.4.3-2 "Non-Class 1E Electrical Room HVAC System Flow Diagram." The staff noted that Figure 9.4.3-3 must be corrected to display the correct system flow diagram for the “Main Steam/Feedwater Piping Area HVAC System.”

The staff requested in RAI 68-841, Question 09.04.03-1, Part 1 that the applicant provide additional information and/or remedies to these inconsistencies in the system descriptions and P&IDs.

In its response dated October 08, 2008 (ML082840131), the applicant indicated that it had revised DCD Subsection 9.4.3 and Figure 9.4.3-1 to make the description consistent. The staff found the applicant’s response to the consistency issues acceptable. In response to the missing “Main Steam/Feedwater Piping Area HVAC System Flow Diagram,” the applicant revised the DCD to include the correct figure in DCD Revision 1. The staff found the applicant’s response to the missing flow diagram issue acceptable. In its response, the applicant committed to address the following two issues in a future revision of the DCD.

- Concerning the system interface between the AB HVAC system and the containment low volume purge system, the applicant proposed revising the DCD to include the additional description of the interface between these systems in DCD Sections 9.4.3.1.2.1 and 9.4.3.2.1 when the filtration unit is utilized.

- In response to the issue of the automatically operated isolation dampers for the AB HVAC System, the applicant clarified that the areas where these dampers are installed are an essential part of the AB HVAC system. Consequently, the applicant proposed revising the DCD to add information to indicate the design classification change in the flow diagram of DCD Figure 9.4.3-1.

The staff confirmed that the applicant revised DCD Sections 9.4.3.1.2.1 and 9.4.3.2.1 and DCD Figure 9.4.3-1 consistent with the above. The staff found the response acceptable and **closed RAI 68-841, Question 09.04.03-1, Part 1.**

SRP 9.4.3 Section IV discusses the review findings for the ABVS including calculations (if applicable) that support the design. The staff requested in RAI 68-841, Question 09.04.03-1, Part 2 that the applicant provide calculation procedures and methods, including assumptions and margins that support the ABVS parameters (e.g. minimum and maximum temperature and humidity values) contained in Table 9.4-1.

The applicant responded in a letter dated October 08, 2008 (ML082840131), that DCD Subsection 9.4.3 Table 9.4-1 shows the design parameters for the temperature and relative humidity of each room, and that these values are not determined from calculation. The applicant clarified that these design values for the system are based on the URD, requirements for the I&C system, and the experience of Japanese PWR plants. The design values for the TSC are the same as for the MCR (See RAI 63, Question 09.04.01-9). The staff substantiated the information contained in Table 9.4-1 against the information contained in the URD for the four subsystems of the ABVS. Based on SRP 9.4.3, guidance that design values do not require a supporting calculation for non-safety related SSCs, the staff found this response acceptable. Based on this conclusion **the staff closed RAI 68-841, Question 09.04.03-1, Part 2.**

SRP 9.4.3 Sections III.1, III.3 and III.4 address use of a FMEA, as appropriate, to confirm that the essential safety-related portions of the system are capable of functioning in spite of the failure of any active component, in the event of an earthquake, during a LOOP, or a concurrent single active failure. The staff found that DCD Section 9.4.3 did not contain any references to COL items for a FMEA for the ABVS. The staff requested in RAI 68-841, Question 09.04.03-1, Part 10 that the applicant provide additional information and clarify if a FMEA was necessary for the ABVS.

In its response dated October 08, 2008 (ML082840131). the applicant agreed to provide a FMEA for the essential safety-related portions of the ABVS. The staff confirmed that an FMEA for the AB HVAC system is included in the DCD as Table 9.4.3-2 (Revision 3). The FMEA addresses the effect regarding system operation of a failure of the safety-related isolation dampers. The staff found the results of the FMEA acceptable and closed **RAI 68-841, Question 09.04.03-1, Part 10**.

SRP 9.4.3 Sections III.1 & IIII.2 require that the reviewer ensure that the P&IDs show: the equipment used; the divisions between essential and nonessential portions of the system; and the temperature limits for the areas serviced. The staff noted that the second paragraph of DCD Section 9.4.3.2.1 “Auxiliary Building HVAC System” states that the cooling coil of each AHU is supplied with chilled water from the non-essential chilled water system (DCD Section 9.2.7). The staff noted that there was no flow diagram (i.e. figure) of the non-essential chilled water system contained in DCD Section 9.0. The staff posited that this missing Figure should display all the heat loads (i.e. number of cooling coils/per AHU) that the non-essential chilled water system supplies with chilled water (e.g. AB AHUs VAS-AAH-201A/B of Figure 9.4.3-1). In the first part of RAI 68-841, Question 09.04.03-1, Part 12, the staff requested that the applicant add this flow diagram to the DCD.

In its response dated October 08, 2008 (ML082840131), to the first part of the RAI 68-841, Question 09.04.03-1, Part 12, the applicant proposed to add the flow diagram and equipment design data for the non-essential chilled water system in DCD Subsection 9.2.7. The applicant also clarified that the flow diagram would include design classifications.

In the second part of RAI 68-841, Question 09.04.03-1, Part 12, the staff noted that the last paragraph of DCD Section 9.2.7 "Chilled Water System" for the "Non-Essential Chilled Water System" states that the function of the non-essential chilled water system is to provide, during plant normal operation and LOOP, chilled water for the plant air cooling and ventilation systems serving the non safety-related areas. Table 8.3.1-5 "Electrical Load Distribution-AAC GTG Loading (LOOP Condition)" does not list any of the ABVSs as a LOOP load. In the second part of RAI 68-841, Question 09.04.01-3, Part 12, the staff also inquired whether any of the MCCs listed in Table 8.3.1- 5 (i.e. P11, P12, P21 and P22) supply power during a LOOP to any other ABVS besides the non-Class 1E electrical room HVAC system and the TSC HVAC system.

The applicant responded that during a LOOP condition, the non-Class 1E electrical room HVAC system and TSC HVAC system are available to be powered by the MCCs. The applicant stated that the AB HVAC system and main steam/feedwater piping area HVAC system are not powered by the AAC power source because the areas served by the AB HVAC system and main steam/feedwater piping area HVAC System are not required to maintain the design temperature and humidity design limits during a LOOP. The staff confirmed that the applicant added a flow diagram and equipment design data for the non-essential chilled water system in DCD Subsection 9.2.7. The flow diagram is displayed on DCD Figure 9.2.7-2 sheets 1 – 3 and includes boundary flags. The staff found the applicant's response acceptable since the guidance of SRP 9.4.3, Section III has been met. The staff **closed RAI 68-841, Question 09.04.03-1, Part 12**.

9.4.3.4.11 ITAAC - 10 CFR 52.47(b)(1)

Compliance with 10 CFR 52.47 requires that a DC application contain proposed ITAAC that are necessary and sufficient to provide reasonable assurance that a facility that incorporates the DC is built and will operate in accordance with the design commitments and meet the applicable NRC regulations. The requirements in 10 CFR 52.47(b) (1) were addressed in the staff's review of Section 9.4.3. The staff reviewed the ITAAC to ensure that the as-built system will comply with the approved system design of the DCD. Specific issues discussed above for ITAAC related items are contained in RAI 68-841, Question 09.04.03-1, Parts 3 and 13 and in RAI 779-5865, Question 09.04.03-16. SER Section 14.3.7, "Plant Systems – Inspections, Tests, Analyses, and Acceptance Criteria" addresses ITAAC in detail.

9.4.3.5 Combined License Information Items

The following is a list of item numbers and descriptions from Table 1.8-2 of the US-APWR DCD. The table was augmented to include "action required by COL applicant/holder."

Table 9.4.3-1
US-APWR Combined License Information Items

Item No.	Description	Section
9.4-4	The COL applicant is to determine the capacity of cooling and heating coils that are affected by site-specific conditions.	9.4.3

COL information items not identified in Table 1.8-2 of the US-APWR DCD: None

9.4.3.6 Conclusions

The staff reviewed the ABVSs to the acceptance criteria defined in NUREG-0800 Section 9.4.3 for acceptability. As set forth above in Sections 9.4.3.3 and 9.4.3.4 of this SE, the US-APWR ABVS has been reviewed along with the RAI responses and US-APWR supporting information to determine if this design adequately meets the guidance given in SRP Section 9.4.3. Some of the responses to the staff's RAIs were incomplete or unacceptable and are addressed by the open items listed below.

The staff maintains the status of the following as outstanding open items and NRC confirmatory items:

- One confirmatory item and one open item contained in the RAI series: RAI 355-2492, Question 09.04.03-3, Confirmatory Item 09.04.03-3; RAI 483-3885, Question 09.04.03-10; RAI 634-4845, Question 09.04.03-12; RAI 779-5865, Question 09.04.03-15 and RAI 6030, Question 09.04.03-21, Open Item 09.04.03-21.

- Open Item -- RAI 68-841, Question 09.04.03-1, Part 9; RAI 355-2492, Question 09.04.03-4 and RAI 6030, Question 09.04.03-17, Open Item 09.04.03-17.

- Open Item -- RAI 68-841, Question 09.04.03-1, Part 13; RAI 355-2492, Question RAI 09.04.03-5(a)(b)(c)(d); RAI 483-3885, Question 09.04.03-08; RAI 4845, Question 09.04.03-13 and RAI 779-5865, Question 09.04.03-16 and three follow-up RAI questions: RAI 6030, Question 09.04.03-18; Open Item 09.04.03-18; RAI 6030, Question 09.04.03-19; Open Item 09.04.03-19 and RAI 6030, Question 09.04.03-20, Open Item 09.04.03-20.

Follow-up questions against all open items have been submitted to the applicant for further evaluation and resolution.

Accordingly, the staff cannot conclude in this SER with Open Items that the applicant meets the relevant requirements of 10 CFR Part 50, Appendix A, GDC 2, 5 and 60.

9.4.4 Turbine Building Area Ventilation System

9.4.4.1 Introduction

The US-APWR DCD Chapter 9.4.4 indicates that the TB area ventilation system maintains a suitable environment for the operation of equipment in the TB. This system includes the following:

- General mechanical areas ventilation system.
- Electrical equipment areas HVAC system.

9.4.4.2 Summary of Application

DCD Tier 1: The Tier 1 information associated with this section is found in DCD Tier 1, Section 2.7.5.5.

DCD Tier 1 Section 2.7.5.5.1 provides a description of the TB area ventilation system. The DCD states that there are no safety-related interfaces with systems outside of the certified design. Also in Tier 1 Section 2.7.5.5.2, the DCD identifies the ITAAC requirements for the TB area ventilation system. These ITAAC are depicted in Table 2.7.5.5-1.

DCD Tier 2: The applicant has provided a Tier 2 description regarding the TB area ventilation system in Section 9.4.4 of the US-APWR DCD, summarized here in part, as follows:

The TB area ventilation system includes the following nonsafety-related subsystems:

- General mechanical areas ventilation system.

- Electrical equipment areas HVAC system.

The general mechanical areas ventilation system consists of TB roof ventilation fans, basement area supply fan, basement area exhaust circulating fan, wall louvers and sampling room HVAC system. This system is a once-through using outdoor air for cooling.

The electrical equipment area HVAC system consists of two 100 percent capacity electrical room AHUs and battery rooms exhaust system.

DCD Tier 2 Section 9.4.4 provides the TB area ventilation system design. The TB area ventilation system is a nonsafety-related system located in the TB. It is a non-seismic category system and not designed to ASME code classifications. The NRC staff evaluation of the TB area ventilation system is provided in Section 9.4.4.4 of this SER.

There are no TS associated with the TB area ventilation system.

Design Basis for Turbine Building Area Ventilation System

Sections of US-APWR DCD Section 9.4.4 describe the TB area ventilation system design basis, system and component description, operation, SE, tests and inspections, and instrumentation applications.

Classification of equipment and components is provided in Tier 2 Section 3.2 of the DCD. Table 9.4.4-1 provides the design parameters of the TB area ventilation system.

DCD Section 9.4.4.3 states that the US-APWR TB area ventilation system has no safety-related function, and therefore has no safety-related design basis.

DCD Section 9.4.4.1 states the TB area ventilation system has the following design bases:

- The general mechanical areas ventilation system is designed to maintain a suitable environment in the general mechanical areas during normal operating condition.

- In the event of the presence of smoke, the general mechanical areas ventilation system purges the smoke in the general mechanical areas.

- The electrical equipment areas HVAC system maintains a suitable environment in the electrical equipment areas during normal operating, LOOP, and SBO conditions.

- In the event of the presence of smoke, the electrical equipment areas HVAC system purges the smoke in electrical equipment areas.

- The electrical equipment areas HVAC system maintains the hydrogen concentration well below two percent by volume in the battery room.

DCD Section 9.4.4.2 provides a description of the TB area ventilation system. Figure 9.4.4-1 depicts the TB area ventilation system. A description of the general mechanical areas ventilation system and electrical equipment areas HVAC system outline system operations.

ITAAC: The ITAAC associated with DCD Tier 2, Section 9.4.4 are given in DCD Tier 1, Section 2.7.5.5.

TS: There are no TS for this area of review.

9.4.4.3 Regulatory Basis

The relevant requirements of the Commission regulations for this area of review and the associated acceptance criteria are given in Section 9.4.4 of NUREG-0800 and are summarized below:

1. GDC 2, Design Bases for Protection Against Natural Phenomena," of Appendix A to 10 CFR Part 50, as related to system capability to withstand the effects of earthquakes.

2. GDC 5, "Sharing of Structures, Systems, and Components," as related to shared systems important to safety.

3. GDC 60, "Control of Releases of Radioactive Materials to the Environment," as related to the capability of the system to suitably control the release of gaseous radioactive effluents to the environment.

4. 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 facility 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.

Acceptance criteria adequate to meet the above requirements are:

1. For GDC 2, "Design Bases for Protection Against Natural Phenomena," acceptance is based on the guidance of RG 1.29, Position C.1 for safety-related portions, and Position C.2 for nonsafety-related portions.

2. For GDC 5, "Sharing of Structures, Systems, and Components," acceptance is based on the determination that the use of the TB area ventilation system in multiple-unit plants during an accident in one unit does not significantly affect the capability to conduct a safe and orderly shutdown and cooldown in the remaining unit(s).

3. For GDC 60, "Control of Releases of Radioactive Materials to the Environment," acceptance is based on the guidance of RG 1.52 and RG 1.140 as related to design, inspection, testing, and maintenance criteria for post-accident and normal atmosphere cleanup systems, ventilation exhaust systems, air filtration, and adsorption units. For RG 1.52, Revision 2, the applicable regulatory position is C.3. For RG 1.140, Revision 1, the applicable regulatory positions are C.1 and C.2. For RG 1.140, Revision 2, the applicable regulatory positions are C.2 and C.3.

9.4.4.4 Technical Evaluation

The staff reviewed DCD Tier 1 and 2 information related to DCD Section 9.4.4, in accordance with SRP Section 9.4.4. The applicant's TB area ventilation system is acceptable if it meets the codes and standards, and the regulatory guidance commensurate with the safety function to be performed. This will ensure that the relevant requirements of GDC 2, 5, and 60, and 10 CFR 52.47(b)(1) are met. The staff's technical evaluation of these requirements is discussed below.

Summary of RAI Exchange

As part of the staff evaluation during the DCD review process, twelve RAIs were prepared and sent to the applicant. Given below are the RAI questions along with the applicant's responses (on September 22, 2008 - ML082681196, on October 08, 2008 - ML082830020, on June 01, 2009 - ML091550467 and on March 30, 2010 - ML100950103) to the staff. After completion of the review of Revision 3 of DCD Section 9.4.4, the staff holds as an open item, the issue associated with RAI 4690, Question 09.04.04-6 (ML101660065), RAI 5555, Question 09.04.04-7 (ML111010025) and RAI 5943, Question 09.04.04-8.

General Design Criterion 2

From its review of DCD Section 9.4.4, the staff found that the design of the US-APWR TB area ventilation system will be both nonsafety-related and nonseismic. This system is located in the Seismic Category II TB. Failure of the TB area ventilation system or its components due to natural phenomena will have no adverse effects on safety related SSCs, since such components are not located in the TB.

The staff reviewed the TB area ventilation system to ensure that the design satisfies the relevant requirements of GDC 2. The staff notes that GDC 2, "Design Bases for Protection Against Natural Phenomena," of Appendix A, "General Design Criteria for Nuclear Power Plants," to Title 10, Part 50, of the *Code of Federal Regulations* (10 CFR Part 50), "Domestic Licensing of Production and Utilization Facilities" (Ref. 1), requires that "nuclear power plant structures, systems, and components (SSCs) important to safety must be designed to withstand the effects of earthquakes without loss of capability to perform their safety functions" . The staff notes that "important to safety" is a broader category than safety-related. The DCD includes the design commitment that "Safety-related equipment is not located in this area." Based on this design commitment, the staff cannot conclude that GDC 2 is met because the scope of important to safety is larger than safety-related. The commitment must be expanded to include the adverse effects on SSCs important to safety or be designed to meet GDC 2.

As noted above, the GDC 2 and RG 1.29 also apply to systems and components "important to safety." The applicant has not demonstrated that failure of ventilation system will not adversely impact the important to safety components in the TB. Based on this, the staff issued RAI 4690, Question 09.04.04-6 (ML101660065) and follow-up RAI 5555, Question 09.04.04-7. In its response dated April 06, 2011 (ML111010025), to RAI 5555, Question 09.04.04-7 the applicant proposed to replace the words of DCD Revision 3 Subsection 9.4.4.1.1 with that clarified that the TB ventilation system is not relied upon for SSC important to safety.

The staff notes that DCD Revision 3 Table 3D-2 (pages 7 and 36) lists the nineteen components "important to safety" located within the TB and designates each as Seismic Category "NON." Given this seismic classification the staff cannot conclude that these components will be designed to withstand the effects of earthquakes without loss of capability to perform their important to safety functions.

The staff holds **the series RAI 4690, Question 09.04.04-6 (ML101660065) and RAI 5555, Question 09.04.04-7 as Open Item 09.04.04-7.** The staff issued **RAI 5943, Question 09.04.04-8 , Open Item 09.04.04-8** as a follow-up RAI to this open item series**.** In Question 09.04.04-8, the staff noted there may be inconsistencies between Chapter 3 and 10. For example, it is unclear from Chapter 10 which important to safety functions these components perform. Clarifying why these components are in Table 3D-2 may aid the staff in coming to a finding regarding GDC 2. The staff also noted that DCD Revision 3 Table 3D-2 (pages 7 and 36) lists the nineteen "important to safety" components located within the TB and designates each as Seismic Category "NON." Given this seismic classification, the staff could not conclude that these components will be designed to withstand the effects of earthquakes without loss of capability to perform their important to safety functions. The staff requested additional information regarding the design of these "important to safety components" that ensures that these components will withstand the effects of earthquakes without loss of capability to perform their important to safety functions. The staff also requested that the applicant amend the applicable sections of the DCD to reflect these design attributes.

General Design Criterion 5

The staff reviewed the TB area ventilation system to ensure that the relevant requirements of GDC 5 are met. Since the design application is for a single unit, GDC 5 does not apply to this system.

General Design Criterion 60

The staff reviewed the TB area ventilation system to ensure that the relevant requirements of GDC 60 are met. Since the TB area is not expected to include airborne radioactive contamination, GDC 60 does not apply to this system.

10 CFR 52.47(b)(1) – Inspections, Tests, Analyses, and Acceptance Criteria

The staff reviewed the TB area ventilation system to ensure the relevant requirements of 10 CFR 52.47(b)(1) address ITAAC. The staff reviewed and asked several questions to better understand the general operation and testing requirements of the TB area ventilation system.

The staff noted that Tier 1 ITAAC Section 2.7.5.5, "Turbine Building Area Ventilation System," identifies three key design features for the system:

1) provide a suitable environment for equipment operation;
2) provide effective smoke evacuation in the building; and
3) maintain the hydrogen concentration below the explosive limit in the battery room.

Subsection C.1 of DCD Section 14.2.12.1.110 identifies four verifications required for preoperational test completion and reads, "Verify manual and automatic controls and functions in the operation and shutdown modes." The staff found that DCD Section 9.4.4.2.1 did not discuss a "shutdown mode." Subsection C.3 reads, "Verify alarms and status indications are functional." The staff found that DCD Section 9.4.4.2.1 did not contain any information about alarms and status indications (e.g., locations of remote and/or local). In RAI 67-715, Question 09.04.04-2, Part 10, the staff requested additional information regarding this absence of detail.

The applicant's response dated October 06, 2008 (ML082830020), noted that DCD Section 9.4.4.5 provides information regarding instrumentation requirements for alarms and status indications. In addition, the applicant explained that the operation and shutdown modes as addressed in DCD Section 14.2.12.1.1.110 are meant to denote normal power operation and normal shutdown modes. Both the operating modes are included in normal operating condition. To provide further clarity to the DCD the applicant amended DCD Section 14.2.12.1.110 to read:

> "C. Test Method: 1. Verify manual and automatic controls and functions in the normal power operation, normal shutdown, and smoke purge modes."

Given the safety significance (i.e., nonsafety-related) of the TB area ventilation system (general mechanical area), the applicant provided an adequate response for the specifics of Subsections C.1 and C.3 of DCD Section 14.2.12.1.110. In addition, the applicant provided a concise change to DCD Section 14.2.12.1.110 Section C.1 that satisfied the guidance of SRP 9.4.5. The staff verified Revision 3 of the DCD included this change. Based on the information provided, the staff found the response acceptable and **closed RAI 67-715, Question 09.04.04-2, Part 10.**

Other SRP 9.4.4 Reviews

TB Environment

SRP 9.4.4 Section III.2.A requires a layout drawing review to ensure the drawings clearly indicate the physical divisions between each portion and specify design classification changes. The staff noted that DCD Figure 9.4.4-1 sheet 2 shows the non-class 1E battery room as a separate space from the electrical room. Figure 9.4.4-1 sheet 2 listed the non-class 1E battery room as a separate area for the TB area ventilation system, DCD Section 9.4.4. In RAI 66-710, Question 09.04.04-1, Part 2, the staff requested the applicant to provide additional detail as to whether the electrical equipment area described in Table 9.4-1 sheet 3 includes the battery room and the electrical room.

The applicant responded on September 22, 2008 (ML082681196), that the "Electrical equipment area of Turbine Building contains electrical room and non-class 1E battery room. Auxiliary building contains non-class 1E electrical room and non-class 1E battery room. Reactor building contains class 1E electrical room. Power source building contains non-class 1E battery room." To provide additional clarity to the DCD, the applicant amended DCD Table 9.4-1 to include a column with Note 2 that describes which building each "area" is located in. The row in Table 9.4-1 sheet 3 for the TB electrical equipment area contains the words "including the electrical room and the non Class 1E battery room." Both of these changes were captured in Revision 1 of the DCD. Based on the information provided, the staff found the response acceptable since the applicant amended the DCD to conform with the guidance of SRP section 9.4.4, Section III.2.A. The staff **closed RAI 66-710, Question 09.04.04-1, Part 2.**

SRP 9.4.4 Section III.1 guides a review for normal and emergency operations and the ambient temperature limits for the areas serviced. The staff noted that DCD Section 9.4.4.2.2 discusses LOOP for the electrical equipment area of the TB. The staff found that this condition (i.e., LOOP) is not listed on sheet 3 of Table 9.4-1 for the electrical equipment area. In RAI 66-710, Question 09.04.04-1, Part 6 the staff requested that the applicant clarify whether the listing of this condition in Table 9.4-1 sheet 3 is appropriate.

In its response dated September 22, 2008 (ML082681196), the applicant agreed to amend the DCD to include LOOP in the Abnormal Temperature columns of Table 9.4-1 for the electrical equipment area of the TB. The staff verified this change has been included in Revision 3 of the DCD. Based on the information provided and the adherence to the guidance of SRP 9.4.4, the staff found the response acceptable. The staff **closed RAI 66-710, Question 09.04.04-1, Part 6**.

To clarify several areas of DCD Section 9.4.4, in RAI 67-715, Question 09.04.04-2, Part 7, the staff asked the applicant the following: 1) what the temperature and humidity ranges listed in DCD Table 9.4-1 for "Abnormal Conditions" represent, 2) what happens to the hydrogen levels in the battery rooms for the duration of the SBO or LOOP event, and 3) whether AAC powers the Turbine Area Ventilation System (TAVS) subsystem electrical equipment areas HVAC system during a LOOP.

In its response of October 06, 2008 (ML082830020), the applicant clarified that: 1) the minimum and maximum values assumed for the electrical equipment areas in Table 9.4-1 are the design conditions if the electrical equipment areas HVAC system is operating; 2) The AAC power source provides power to the TB area ventilation system (electrical equipment area) including the battery rooms exhaust fans. This system is operational for SBO and LOOP events when the AAC source becomes available. Therefore, this system can maintain the hydrogen and ambient temperatures within the design conditions during SBO and LOOP conditions; and 3) the electrical equipment areas HVAC system derives power from the AAC power source during a LOOP and SBO to allow the chilled water system to supply chilled water to the cooling coils of the non-class 1E electrical equipment area AHU to maintain a suitable environment for the equipment operating in the electrical equipment area. The applicant concluded its response with a proposed amendment to the DCD by adding a last sentence to the first paragraph in Section 9.4.4.2.2 stating, "This HVAC system is powered from the AAC power source and operated during SBO and LOOP conditions." The applicant provided a comprehensive response to the list of staff questions. In addition, the applicant provided a change to DCD Section 9.4.4.2.2 that fully addressed staff concerns. Based on the details of the response to RAI 9.4.4-7 and the commitment to revise the DCD, the staff found the response acceptable.

The staff found during its review of Revision 2 of the DCD (and now Revision 3) that the applicant did not amend the DCD with the above words (verbatim). Instead the applicant amended Section 9.4.4.2.2, "Electrical Equipment Areas HVAC System" of Revision 2 to the DCD stating:

> "The electrical equipment areas HVAC system consists of two 100% non-Class 1E electrical room air handling units and non-Class 1E battery rooms common exhaust system. This HVAC system is powered from the alternate ac power source and operated during LOOP condition."

This change resulted in a changed technical meaning. Based on this finding the staff issued follow-up RAI 541-4346, Question 09.04.04-4 to determine why the change occurred. The applicant responded on March 30, 2010 (ML100950103), stating:

> "Originally, the non-Class IE electrical room air handling units which supply cooling and ventilation for the batteries and distribution systems were required to

> be in service during a SBO event. However, a revision (See DCD Revision 2) relocated the switching circuit to the Power Source Building, which eliminates the need for the non-class 1E electrical room air handling units during a SBO. For this reason, the current description does not include SBO."

The staff found the applicant's explanation to be acceptable since the non-class 1E electrical room AHUs are still powered by an AAC power source during a LOOP but these AHUs are not required for an SBO. The staff **closed both RAI 67-715, Question 09.04.04-2, Part 7 and RAI 541-4346, Question 9.04.04-4.**

Fire Response/Smoke Removal/Battery Room Hydrogen Removal Evaluation

The staff reviewed and asked several questions to understand the fire protection interfaces, smoke purge operation, and its testing requirements.

To address fire protection concerns, the staff requested additional information regarding the response of the TB area ventilation system to the presence of smoke or fire within the building. The staff noted that the third paragraph of DCD Section 9.4.4.2.1 read, "In the event of the presence of smoke, selected roof fans are actuated to purge the smoke." The staff found this passage unclear as to whether the actuation of roof fans to purge smoke from the general mechanical areas is manual or automatic. Accordingly, in RAI 67-715, Question 09.04.04-2, Part 9, the staff asked the applicant the following questions:

- What controls, alarms and displays, and/or logic and interlocks are relevant for smoke or fire detected in this area?
- If a fire were detected in the TB, would the 27 roof fans automatically shut down until the fire is extinguished?
- Are there different fan speeds associated with the roof fans for normal operation versus the smoke purge mode?

The applicant responded on October 06, 2008 (ML082830020), stating:

> "If a fire is detected in the Turbine Building, all 27 roof fans shut down automatically. Once the fire has been extinguished, smoke purge operation is initiated manually by restarting fans as needed from the MCR. Different fan speeds are not required for Turbine Building roof ventilation fans for normal operation versus the smoke purge mode. There is enough flexibility in selecting numbers of fans required for smoke purge mode. Smoke control and removal function for the Turbine Building is identified in DCD Appendix 9A, Section 9A.3.96. However, smoke control features are addressed in DCD Tier 2 Appendix 9A, Section 9A.3.96 FA FA6-101, as follows:
>
> Smoke Control Features
>
> The Turbine Building is provided with automatic opening smoke vents in the building roof. Supplementary smoke removal can be accomplished by the plant fire brigade using portable fans and ducting and standard firefighting techniques. Except for isolated rooms, smoke accumulation is not expected to be a problem due to the tremendous internal volume of the building. This is different from what

> is stated in DCD Section 9.4.4.2.1, which states that selected roof fans are actuated to purge the smoke."

To remove any areas of ambiguity or conflict within the DCD, the applicant proposed to revise the DCD with the following two amendments:

1) Revise third paragraph in DCD Section 9.4.4.2.1 as follows:

   "In the event of the presence of smoke, selected roof fans are actuated to purge the smoke. If a fire is detected in the Turbine Building, all 27 roof fans shut down automatically. Once the fire has been extinguished, smoke purge operation is initiated manually by restarting fans as needed from the Main Control Room."

2) Revise DCD Appendix 9A, Section 9A.3.96 FA6-101 under "Smoke Control Features" as follows:

   "The turbine building area ventilation system is manually actuated to purge the smoke. Supplementary smoke removal can be accomplished by the plant fire brigade using portable fans and ducting and standard firefighting techniques. Except for isolated rooms, smoke accumulation is not expected to be a problem due to the tremendous internal volume of the building."

The applicant provided an adequate response to the list of staff questions. In addition, the applicant provided changes to DCD Section 9.4.4.2.1, and DCD Appendix 9A, Section 9A.3.96, which fully addressed staff concerns in regard to the above fire protection issues. Based on details of the response to RAI 67-715, Question 09.04.04-2, Part 9 and the proposed amendment to the DCD, the staff found the response acceptable.

The staff found during its review of Revision 2 of the DCD that the applicant did not amend the DCD with the above words. Based on this finding the staff issued follow-up RAI 541-4346, Question 09.04.04-5 to determine why the change had not occurred. The applicant responded to RAI 541-4346, Question 09.04.04-5, dated March 30, 2010, (ML100950103) by agreeing to revise, *"… DCD subsection "9A.3.131 FA6-101 Turbine Building" for "Smoke Control Features"* with further clarification.

Based on the proposed change to the DCD, the staff found the applicant's response acceptable. The staff confirmed that DCD Revision 3 Subsection "9A.3.131 FA6-101 contains the requisite changes. Based on this, the staff **closed RAI 67-715, Question 09.04.04-2, Part 9 and RAI 541-4346, Question 09.04.04-5.**

The staff noted that fire protection system Figure 9.4.4-1 (Sheet 2 of 2) displays six symbols in the flow process lines. These symbols were not identified in the figure "Legends for Piping and Instrumentation Diagrams of HVAC System," in any legend contained in DCD Chapter 9, or in Tier 1. The staff's review of DCD Section 9.5 and Reference Table 9A-3 for Fire Zones FA6-101-03 and FA6-101-14 and Figures 9A-21 and 9A-22 led the staff to conclude that the six symbols most likely represent fire dampers. In RAI 67-715, Question 09.04.04-2, Part 12, the staff requested that the applicant remove the ambiguity of the six symbols from the DCD Section 9.4.4. The staff also requested that, if these symbols do represent fire dampers, the applicant describe them as a fire protection system interface in DCD Section 9.4.4 with respect to the TB ventilation system.

The applicant responded to RAI 67-715, Question 09.04.04-2, dated October 06, 2008 (ML082830020), by concurring that the symbols are ambiguous and do represent fire dampers. The applicant provided a revision to the DCD by inserting the following text after the last paragraph of DCD Section 9.4.4.2.2: "*All duct penetrations in the fire walls are protected by fire dampers to prevent the spread of fire from an affected area to the adjacent redundant component areas."* Figure 9.4.4-1 (Sheet 2 of 2) will also be revised to add a legend for the fire dampers. The applicant provided an adequate response to staff concerns by clarifying the existence of and the location of fire dampers in DCD Section 9.4.4. The staff verified these changes have been included in Revision 3 of the DCD. Based on the information provided, the staff found the response acceptable and **closed RAI 67-715, Question 09.04.04-2, Part 12.**

DCD Section 9.4.4.2.2, pertains to the automatic response of the AHUs in the presence of smoke. This DCD section also indicates that the battery rooms' common exhaust has two 100 percent common exhaust fans, with one in standby, designed to maintain the hydrogen concentration well below twp percent by volume in the battery rooms. The staff found this section unclear as to what controls, alarms, and displays and/or logic and interlocks are relevant in the event of an abnormal hydrogen build up in the battery rooms. Accordingly, in RAI 67-715 Revision 0, Question 09.04.04-2, Part 11, the staff requested the following information: 1) if abnormal hydrogen builds up in either of the battery rooms, how would the two exhaust fans react; and 2) would the presence of smoke cause any type of response by the two non-Class 1E Battery Room Exhaust Fans?

In its response dated October 06, 2008 (ML082830020), the applicant provided the following two DCD amendments: Revise paragraph four in DCD Section 9.4.4.2.2 to read as follows: "*The battery rooms common exhaust system has two 100 percent exhaust fans, with one in standby. When one fan fails, the fan failure is alarmed in the main control room and the other one starts automatically. This system maintains the hydrogen concentration well below 2 percent by volume in both battery rooms."* Revise DCD Section 9.4.4.2.2 by adding the following sentence at the end of the last paragraph: "*The exhaust fans for the battery rooms will not trip on smoke detection.*" The applicant in its response provided concise changes to DCD Section 9.4.4.2.2 that fully resolved the staff concerns identified in RAI 67-715, Question 09.04.04-2, Part 11. The staff verified this change has been included in Revision 2 of the DCD. From the review of DCD Revision 3, Section 9.4.4.2.2, the staff notes that the last sentence of the fourth paragraph reads "This system maintains the hydrogen concentration well below 1 percent by volume in both battery rooms." Since this a more conservative value, the staff accepts this change without the need for further clarification from the applicant. Based on the information provided, the staff found the response acceptable and **closed RAI 67-715, Question 09.04.04-2, Part 11.**

9.4.4.5 Combined License Information Items

The staff reviewed the COL information items as listed in DCD Tier 2 Section 1.8.2 and found that there are no items relevant to the TB area ventilation system. The staff concluded that this is appropriate and no COL information items are needed for the TB area ventilation system.

9.4.4.6 Conclusions

The staff evaluated the TB area ventilation system for the US-APWR standard plant design in accordance with guidance that is referred to in the technical evaluation section of this SE. Based on this review, the staff concludes that sufficient information has been provided by the applicant in the US-APWR DCD Tier 1 Section 2.7.7.5 and Tier 2 Section 9.4.4. In addition, the staff compared the design information in the DC application to the relevant NRC regulations, acceptance criteria defined in NUREG-0800 - SRP Section 9.4.4, and other NRC RGs. In conclusion, with the noted exception regarding GDC 2, the US-APWR design for the TB area ventilation system is acceptable 10 CFR 52.47(b)(1), and the guidelines of SRP Section 9.4.4 for protection against natural phenomena and control of releases of radioactive materials to the environment. Compliance with GDC 2 is being tracked as an open item.

As set forth in Sections 9.4.4.3 and 9.4.4.4 of this SE, the US-APWR TB area ventilation system does not serve any safety-related function, and thus has no safety design bases.

The following item remains open:

> **RAI 4690, Question 09.04.04-6 (ML101660065), RAI 5555, Question 09.04.04-7 , Open Item 09.04.04-7 (ML111010025) and RAI 5943, Question 09.04.04-8 , Open Item 09.04.04-8 is listed as pending the applicant's complete resolution to the issues documented in these RAI questions**.

Responses to other staff RAIs and revisions to the DCD completed by the applicant have resolved the staff concerns and are acceptable. The staff closes all other RAI questions associated with this DCD section. Accordingly, the staff concludes that the applicant meets the relevant requirements of 10 CFR Part 50, Appendix A, GDC (not 2,) 5, and 60 and 10 CFR 52.47(b)(1) and that DCD Section 9.4.4 is acceptable subject to the closure of the above open item.

9.4.5 Engineered Safety Feature Ventilation System

9.4.5.1 Introduction

The US-APWR indicates the ESF ventilation system is designed to provide the proper environmental conditions within plant areas that house ESF equipment. The system function is to support and assure the safe and continuous operation of the ESF equipment during normal and emergency operating conditions. The ESF ventilation system is designed to comply with 10 CFR 50.63, 10 CFR 52.47(b) (1) and 10 CFR 50 Appendix A GDC 2, 4, 5, 17 and 60.

The ESF ventilation system is designed to satisfy the following safety design bases:

- The ESF ventilation system is classified as a safety-related and Seismic Category I system.
- Redundant ventilation systems are powered by separate safety-related buses so that failure of a single active component cannot result in loss of cooling for the served areas.
- The system is capable of performing the intended design functions assuming a single active component failure coincident with a LOOP.

- The system can withstand the effects of adverse environmental conditions.

- The system can withstand the effects of tornado depressurization and tornado-generated missiles.

- 10 CFR 50, Appendix A, GDC 17 is satisfied in part for the essential electrical components of the ESF Ventilation System, such as contacts and relays. This is accomplished by protecting the components from accumulated dust and particulate materials by enclosing the components in dust-tight cabinets and taking outdoor air through air filters from a height of at least seven meters (20 feet) above ground level.

9.4.5.2 Summary of Application

DCD Tier 1: The Tier 1 information associated with this section is found in DCD Tier 1, Section 2.7.5.2.

DCD Tier 2: The applicant has provided a Tier 2 description of the ESF ventilation system in Section 9.4.5 of the US-APWR DCD, summarized here in part, as follows:

> The ESF ventilation system includes the following subsystems:
>
> - Annulus emergency exhaust system.
> - Class 1E electrical room HVAC system.
> - Emergency feedwater pump area HVAC system.
> - Safety-related component area HVAC system.
>
> In addition, the DCD states that a site-specific ESW pump area ventilation system, if required, is to be provided by the COL applicant.
>
> The annulus emergency exhaust system is an ESF system designed for fission product removal and retention. It consists of two redundant 100 percent capacity divisions. The system is shown in Figure 9.4.5-1 and the system equipment design data is presented in Table 9.4.5-1.
>
> The Class 1E electrical room HVAC system consists of four redundant trains, each sized to satisfy 100 percent of the cooling and heating demand of two trains, i.e., train A or B can provide cooling and heating for both trains A and B, and train C or D can provide cooling and heating for both trains C and D. The system is shown in Figure 9.4.5-2 and the system equipment design data is presented in Table 9.4.5-1. The table provides design capacities for cooling coils. The capacities of the heating coils for the system affected by site-specific conditions are provided by the COL applicant.
>
> During normal operation, safeguard component areas are served by the AB HVAC system discussed in Section 9.4.3. During a DBA or LOOP, the safeguard component areas are cooled by individual AHUs. Each AHU consists of an electric heating coil, a cooling coil, a supply fan and associated controls. The system is shown in

Figure 9.5.4-3 and the equipment design data is presented in Table 9.4.5-1. The table provides design capacities for cooling coils. The capacities of the heating coils for the system affected by site-specific conditions are provided by the COL applicant. The cooling coils are supplied with chilled water from the essential chilled water system, discussed in Section 9.2.7.

During normal operation, EFW pump (motor-driven) areas are served by the AB HVAC system discussed in Section 9.4.3. During a DBA or LOOP, the EFW pump (turbine-driven) areas are cooled by individual AHUs. The EFW pump (motor-driven) area AHU consists of an electric heating coil, a cooling coil, a supply fan and associated controls. The EFW pump (turbine-driven) area AHU consists of a low-efficiency filter, an electric heating coil, a cooling coil, a supply fan and associated controls. The system is shown in Figure 9.5.4-4 and the equipment design data is presented in Table 9.4.5-1. The table provides design capacities for the cooling coils. The capacities of the heating coils for the system affected by site-specific conditions are provided by the COL applicant.

During normal plant operation safety-related component areas are served by the ABVS discussed in Section 9.4.3. During a DBA or LOOP, the areas are cooled by individual AHUs. Each of the AHUs consists of an electric heating coil, a cooling coil, a supply fan, and associated controls. The system is shown in Figures 9.4.5-1 and 9.4.5-5 and the equipment design data is presented in Table 9.4.5-1. The table provides design capacities for the cooling coils. The capacities of the heating coils for the system affected by site-specific conditions are provided by the COL applicant.

ITAAC: The ITAAC associated with DCD Tier 2, Section 9.4.5 are given in DCD Tier 1, Section 2.7.5.2.

TS: There are no TS for this area of review.

9.4.5.3 Regulatory Basis

The staff reviewed DCD Tier 1 and 2, Section 9.4.5, “Engineered Safety Feature Ventilation System,” in accordance with SRP Section 9.4.5. The applicant’s ESF ventilation system is acceptable if it meets the codes, standards, and regulatory guidance commensurate with the safety function to be performed. This will ensure that the system design satisfies the relevant requirements of GDC 2, 4, 5, 17, and 60, 10 CFR 50.63 and 10 CFR 52.47(b). These requirements are discussed below.

- GDC 2, “Design Bases for Protection Against Natural Phenomena,” as related to the system being capable of withstanding the effects of earthquakes.

- GDC 4, “Environmental and Dynamic Effects Design Bases,” with respect to the ESF ventilation system being appropriately protected against dynamic effects and being designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents. The evaluation with respect to GDC 4 also includes evaluation of the adequacy of environmental support provided to SSCs important to safety located within areas served by the ESF ventilation system.

- GDC 5, "Sharing of Structures, Systems, and Components," as related to shared systems and components important to safety.

- GDC 17, “Electric Power Systems,” as related to ensuring proper functioning of the essential electric power system.

- GDC 60, "Control of Release of Radioactive Materials to the Environment," as related to the systems capability to suitably control release of gaseous radioactive effluents to the environment.

- 10 CFR 50.63 as related to necessary support systems providing sufficient capacity and capability for coping with a SBO event. An analysis to determine capability for withstanding (if an acceptable AAC source is provided) or coping with an SBO event is required. The analysis should address, as appropriate, the potential failures of equipment/systems during the event (e.g., loss of or degraded operability of HVAC systems, including the ESF ventilation system, as appropriate), the expected environmental conditions associated with the event, the operability and reliability of equipment necessary to cope with the event under the expected environmental conditions, and the habitability of plant areas requiring operator access during the event and associated recovery period.

- 10 CFR 52.47(b) (1), which requires that a DC 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 facility 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.

9.4.5.4 Technical Evaluation

The staff reviewed the ESF ventilation system for the US-APWR in accordance with SRP Section 9.4.5.

Summary of RAI Exchange

As part of the staff evaluation during the DCD review process, 24 RAIs were initially prepared and sent to the applicant as captured in RAI 64-675 (ML082830021). Follow-up RAI 356-2549 (ML092030375) and RAI 474-3811 (ML093210470) were issued after the staff assessed the sufficiency of the applicant’s answers to RAI 64-675. RAI 583-4554 (ML101760191) was issued based on the staff’s review of Revision 2 of the DCD. Other RAI questions and applicant responses of relevance to this SER are: RAI 184-1912 (ML091040177); RAI 442-3878 (ML092650173); RAI 484-3850 (ML093480146); RAI 539-4329 (ML100960032); RAI 690-4908 (ML110770287) and RAI 670-4773 (ML110040148). Most of the RAI questions are discussed below, along with the applicant’s responses and the staff’s evaluation of each. The staff omitted from the discussion in this SER, several of the RAI questions due their lack of significance in making the regulatory findings.

General Design Criterion 2

The staff reviewed the ESF ventilation system to ensure that the DCD satisfied the relevant requirements of GDC 2. The staff's review ensured that the system design was capable of withstanding the effects of earthquakes by meeting the guidelines of RG 1.29, "Seismic Design Classification," Position C.1 for essential safety related portions of the system. The staff notes that DCD subsection 9.4.5.1.1 "Safety Design Basis" for the ESF ventilation system reads "ESF ventilation system is classified as a safety-related and seismic category I system." Similarly DCD Section 9.4.5 reads "The ESF ventilation system complies with 10 CFR 50, Appendix A, GDC 2, 4, and 60." The staff also notes that Item 2 of DCD Tier 1 Table 2.7.5.2-3 "Engineered Safety Features Ventilation System Inspections,Tests, Analyses, and Acceptance Criteria." will ensure that the as-built ESF ventilation system is constructed to satisfy Seismic Category I requirements.

The staff concluded that the ESF ventilation system as described in the US-APWR DCD satisfies the requirements of GDC 2.

General Design Criterion 4

The staff reviewed the ESF ventilation system to ensure that the system design satisfied the relevant requirements of GDC 4. SRP Sections 3.5.1.1, 3.5.1.4, 3.5.2, and 3.6.1 serve as the standard for GDC 4 compliance. The staff evaluated the particular design attributes of the system with respect to the protection of SSC from the dynamic effects associated with postulated accidents. This includes the effects of missiles, pipe whipping, and discharging fluids that may result from equipment failures and events and conditions outside the nuclear power unit.

The GDC 4 "Technical Rationale" from SRP 9.4.5 Section II "Acceptance Criteria" reads:

> "The function of the ESFVS is to provide a suitable and controlled operating environment for engineered safety feature components during normal operation, during adverse environmental occurrences, and during and subsequent to postulated accidents, including loss of offsite power. This requirement is imposed to ensure that engineered safety features function through the course of operating and accident events. In addition, the ESFVS design must withstand dynamic effects associated with postulated accidents."

During the review of DCD Section 9.4.5, the staff could not find any reference to a FMEA for the ESF ventilation system. In RAI 64-735, Question 09.04.05-01, Part 10, the staff requested that the applicant provide additional information or justify as to why a FMEA is not necessary for the ESF ventilation system. In its response of October 06, 2008 (ML082830021), the applicant agreed to perform a FMEA for the ESF ventilation system. The applicant included the FMEA results for the essential safety-related portions of the ESF ventilation system in DCD Revision 2 DCD Table 9.4.5-2.

The staff had additional questions regarding the results of the FMEA as captured in RAI 583-4554, Question 09.04.05 11. The staff's questions centered around: (a) the tornado dampers contained in the design of the annulus emergency exhaust system, the Class 1E electrical room HVAC system and the EFW pump HVAC system; and (b) the cooling coils for four of the subsystems that comprise the ESF ventilation system.

In response to the staff's RAI about the tornado dampers and their lack on inclusion in the FMEA Table 9.4.5-2, the applicant provided a response on June 22, 2010 (ML101760191), for the applicable subject ESF subsystems. The response detailed how the dampers functioned in tornadic conditions. The applicant explained that the tornado dampers will be self actuated by the pressure differential created by the tornado-produced environmental conditions. The dampers do not require external motive force (such as an actuator or manual operation) to change position. Therefore, the applicant concluded that the dampers are considered passive devices and are not evaluated in FMEA Table 9.4.5-2.

As a result of the staff's questioning, the applicant did discover one design flaw, in that there was only one tornado damper in the common exhaust line from the annulus emergency exhaust system. To correct this condition, the applicant changed the annulus emergency exhaust system description to include a tornado damper in each train exhaust line. Based on this finding, the applicant agreed to make changes to DCD Tier 1 Table 2.7.5.2-1 and Figure 2.7.5.2 1 and Tier 2 Figures 6.5 1 and 9.4.5 1 to include a tornado damper in the exhaust lines in each of the two divisional trains of the annulus emergency exhaust system. The staff verified that Revision 3 of the DCD contained the needed changes to DCD Tier 1 Table 2.7.5.2 1 and Figure 2.7.5.2-1 and Tier 2 Figures 6.5-1 and 9.4.5-1.

In addition, for the EFW pump area HVAC system, the applicant agreed to add a concise description of the tornado dampers to DCD subsection 9.4.5.2.4 and 9.4.5.3.4.
The staff evaluated the applicant's proposed DCD Tier 1 and Tier 2 changes as acceptable since the changes resolve the DCD deficiencies with a comprehensive fix for the subject issue of tornado dampers. The staff verified that Revision 3 of the DCD contained the changes to Subsections 9.4.5.2.4 and 9.4.5.3.4.

The staff also noted in RAI 583-4554, Question 09.04.05-11 that for the cooling coils of the AHUs, Table 9.4.5-2 does not address two failure modes of concern: (1) What design features will prevent the failure of an essential chilled water cooling coil leak inside the AHUs from adversely impacting the safety related components contained in these same rooms? (2) DCD Subsection 9.2.7.2.1.1 reads "The valve failure position at the loss of a control signal and electrical power is "as is" "for the "Chilled Water Control Valves." What is the implication of this mode of failure with respect to the ventilation system? The staff asked two similar questions for the four subsystems of the ESF ventilation system that contain cooling coils.

The applicant responded on June 22, 2010 (ML101760191), to the first question with a similar response for all four subsystems. In particular the applicant indicated that the AHU housing is designed to facilitate removal of water leaked from the cooling coil as described in Section 3.4.1.5.2.2. Water leaked from the cooling coil is drained to the nonradioactive drain sump via the drain system.

The staff evaluated this part of the applicant's response as insufficient for the reasons cited in RAI 690-4908, Question 09.04.05-19. The staff cited DCD Section 9.3.3.4.1 "Testing During Construction" and the first sentence of Section 9.3.3.4.2 "Operational Testing Capability" which reads: "The operability of equipment and floor drainage systems dependent on gravity flow can be checked by normal usage." The staff observed that the construction test is a leak test of the drain piping rather than full flow test and fails to demonstrate that the drain line can accommodate the drainage from a leaking cooling cool. In addition, the staff observed that the operational testing is of limited value in that cooling coil condensate flow rates would most likely be much less than the drain pipe flow rates experienced during a cooling cool leak.

Based on this, the staff requested that the applicant enhance preoperational test 14.2.12.1.116 "Equipment and Floor Drainage System Test" to demonstrate the capability of the equipment and floor drain systems to route worst case flood waters and equipment cooing-coil leakage away from safety-related equipment throughout the US APWR plant. In addition, the staff requests additional information about what plant maintenance programs will ensure that the equipment and floor drain lines are capable of their design function throughout the plant life cycle.

In its response dated March 15, 2011 (ML110770287), the applicant referred the staff to its response to RAI 689-4976, Question 09.04.01-25, and then stated that the safety-related, Seismic Category I Class 1E electrical room HVAC system, safeguard component area HVAC system, EFW pump area HVAC system, and safety-related component HVAC system chilled water cooling coils are not postulated to fail. Therefore, the associated AHUs equipment drains are not required to be designed for the failure of the pressure boundary of the cooling coils.

As described in DCD Section 9.3.3.3.1, the equipment and floor drainage systems are not safety-related and perform no safety function, except for valves that are provided to isolate drainage piping in ESF equipment rooms. As further described in DCD Section 3.4.1.5.2.1, floor drains are not credited in the flooding evaluation. Therefore, no demonstration of the capability to route worst case flood waters is required.

The applicant concluded that no enhancement to DCD Section 14.2.12.1.116 is necessary. The design capacity is adequate and consistent with the equipment and floor drainage system design basis. Maintaining drain systems clear and free-flowing is a normal plant operation and maintenance activity. The plant maintenance program is addressed in DCD Chapter 13, and operating and maintenance procedures are developed by the COL Applicant as stated in DCD Section 13.5.2.

The staff found the applicant's response to the first part of RAI 583-4554, Question 09.04.05-11 acceptable based on the facts that the floor drains are a nonsafety-related system and that divisional separation between the AHUs of the ESF ventilation subsystems prevents a single failure, cooling coil leak in one AHU from affecting safety-related equipment in other divisional trains.

To the staff's second cooling coil question of RAI 583-4554, Question 09.04.05-11, the applicant indicated (ML101760191) that upon high temperature in the respective ESF area/room the associated chilled water control valve is automatically positioned for maximum chilled water flow. However, as described in 9.2.7.2.1.1, the chilled water control valves fail 'as is'. Therefore, when a chilled water control valve fails, the associated AHU train loses its ability to control the ESF area/room temperature and is removed from service. The remaining safety-related ESF AHU trains of the respective subsystem remain available and satisfy the requirements of GDC 4.

The applicant proposed a change to DCD Table 9.4.5-2, that added the failure mode "Loss of room temperature control upon demand signal" to Items 2.1, 3.1, 4.1 and 5.1 through 5.6.

The staff found the applicant's resolution of the issues raised in the second question, comprehensive in scope for all four subject subsystems of the ESF ventilation system. Based on this, the staff found acceptable the proposed changes to Table 9.4.5-2. The staff verified that Revision 3 DCD Table 9.4.5-2 contains the failure mode described for the above "Items." Based on this, the staff closed the second part of the cooling coil question to RAI 583-4554, Question 09.04.05-11. Based on the foregoing, the staff **closed RAI 64-735, Question**

09.04.05-01, Part 10; RAI 583-4554, Question 09.04.05-11; and RAI 4908, Question 09.04.05-19.

DCD Section 9.4.5.2.2 reads, "Rooms with high heat loss during the cold season are provided with non safety-related in duct electric heaters in their supply air branches." The staff found that DCD Table 9.4.5 1 does not reflect the existence of these in duct heaters. In RAI 64-735, Question 09.04.05-01, Part 11, the staff recommended that the applicant add a placeholder labeled “COL 9.4(4)" to Table 9.4.5-1 to ensure the applicant addresses this requirement. The applicant responded on October 06, 2008 (ML082830021), that the induct heaters are not considered a major component and are designed as Equipment Class 5 and Seismic Category II. The applicant concluded its response with an amendment to DCD Section 9.4.5.2.2 that identifies the equipment classification of in duct heaters in Revision 2 of the DCD. The staff found this DCD change appropriate and acceptable.

The staff further reviewed the subsystems that comprise the ESF ventilation system. From this review, the staff determined that only the Class 1E electrical room HVAC subsystem contains in duct heaters. The staff notes that the acceptance criteria of line item 4b of ITAAC Table 2.7.5.2-3 (per the MHI response to RAI 184-1912, Question 14.03.07-26 (ML091040177) reads:

> “The as built Class 1E electrical room HVAC system is capable of providing conditioning air to maintain area design temperature limits within the Class 1E electrical rooms during all plant operating conditions, including normal operations, abnormal and accident conditions.”

Therefore, through tests and analyses, the in duct heaters of the Class 1E electrical room HVAC system will be demonstrated capable of maintaining the operability of safety-related equipment regardless of where the plant is located within the United States. Based on this, the staff concluded that the concerns of RAI 64-735, Question 09.04.05-01, Part 11 and RAI 356-2549, Question 09.04.05-7 were fully resolved. Accordingly, the staff **closed RAI 64-735, Question 09.04.05-01, Part 11.**

The staff noted that DCD Section 9.4.5.2.5, "Safety Related Component Area HVAC System," states that, upon safety-related component area high temperature, the chilled water cooling coil control valve for the corresponding AHUs is automatically positioned for full chilled water flow to prevent the temperature rise. This system function is reflected in each of the figures for each of the 16 individual AHUs for the temperature control valves displayed on Figure 9.4.5-1 and Figure 9.4.5-5. The figures for each of the AHUs also display instrumentation to each of the AHU fans. For example, Figure 9.4.5-5 (Sheet 2 of 2) for the "B Charging Pump Area AHU" displays instrumentation TS2738 and TC2738, and TS2739 and TC2739 to the fan. The staff found that neither DCD Tier 2 Section 9.4.5.2.5 nor Figure 1.7-2, “Legend for Instrument and Control Function Diagrams” explained the function of this instrumentation with respect to the fans.

In RAI 64-735, Question 09.04.05-01, Part 13, the staff requested that the applicant provide further information about the function of instrumentation such as TS2738 and TC2738, and TS2739 and TC2739. The staff requested that the applicant also expand their response to address similar concerns about the instrumentation associated with the AHUs of the EFW pump HVAC system and safeguard component area HVAC system.

The applicant in its response of October 06, 2008 (ML082830021), provided changes to DCD Subsections 9.4.5.2.3, 9.4.5.2.4, and 9.4.5.2.5 for each of the ESF HVAC subsystems identified in RAI 9.4.5-13. The staff confirmed that the changes incorporated into Revision 3 of the DCD fully clarified the function of the subject instrumentation with respect to each subsystem's operation. The staff found that the applicant comprehensively resolved the staff's concern as documented in RAI 9.4.5-13. Accordingly, the staff found the response acceptable and **closed RAI 64-735, Question 09.04.05-01, Part 13.**

In RAI 64-735, Question 09.04.05-01, Part 19, the staff requested that the applicant describe in DCD Section 9.4.5, the transfer of three subsystems from normal mode of operation to emergency mode. The subject subsystems are: (1) the safeguard component area HVAC system; (2) the EFW pump HVAC system; and (3) the safety related component area.

In its response dated October 06, 2008 (ML082830021), the applicant explained that DCD s ubsections 9.4.5.1.1.3, 9.4.5.2.1 and 9.4.5.2.3 already sufficiently explain the transfer from normal mode to emergency mode for the safeguard component area HVAC system. The applicant agreed that there was a need to amend the DCD with more detail about the transferring between normal to emergency modes of operation for both the EFW pump (motor and turbine driven) HVAC system and the safety-related component area HVAC system. The applicant agreed to revise DCD subsections 9.4.5.2.4 and 9.4.5.2.5, accordingly. Upon review of Revision 3 of the DCD, the staff found that the DCD adequately described the transferring of all three of these systems from the normal mode of operation to the emergency mode of operation. Accordingly, the staff found the applicant's RAI response acceptable since the DCD now reflects the design function of the ESF ventilation system to provide a suitable and controlled operating environment for ESF components during normal operation, during adverse environmental occurrences, and during and subsequent to postulated accidents, including LOOP. This function is a basic premise of conformance to GDC 4 and GDC 60 as defined in SRP 9.4.5 Section II "Acceptance Criteria". Based on this, the staff **closed RAI 64-735, Question 09.04.05-01, Part 19.**

DCD Section 9.4.5.4 states that the AHUs airflows are balanced to provide proper air mixing throughout the served areas. The staff found that neither DCD Section 9.4.5 nor its related tables and figures provide design airflow rates to ensure proper air mixing and, as in the case of the annulus emergency exhaust system, to ensure the capability to control airborne particulate material accumulation as required by SRP 9.4.5 Section 1.2. In RAI No. 64-735, Question 09.04.05-01, Part 22, the staff requested that the applicant provide design airflow rates to the plant areas served by the ESF ventilation system.

The applicant's response of October 06, 2008 (ML082830021), failed to provide additional information regarding design flow rates for the four subsystems of the ESF ventilation system beyond what was already in the DCD. The applicant indicated that design air flow rates required for proper air mixing throughout the various areas served by the ESF ventilation systems will be decided during the detailed design phase.

In followup RAI 356-2549, Question 09.04.05-9, the staff requested that the applicant fulfill the staff's request of RAI 64-735, Question 09.04.05-01, Part 22, or alternatively, establish an ITAAC or Condition for Licensing to provide a guarantee that the COL applicant complies with the guidance of SRP 9.4.5.

In its response of July 17, 2009 (ML092030375). the applicant provided the details of how the heat loads were calculated for each of the cooling coils of DCD Table 9.4.5-1. In addition, the applicant established ITAAC line items 4.b through 4.f of Tier 1, Table 2.7.5.2-3 (Reference RAI 474-3811, Question 09.04.05-10). These ITAAC will verify the correct sizing of the heating and cooling subsystems and verify the establishment of correct airflow rates for the ESF ventilation subsystems in maintaining area temperatures. The staff finds this use of ITAAC appropriate and resolves the most salient issue of RAI 64-735, Question 09.04.05-01, Part 22.

Based on review of the additional information provided, the staff elected to audit the calculations that generated the numbers contained in the DCD Table 9.4.5-1. From May 24 - 28, 2010, the staff performed an Audit (ML110800203) during which the staff reviewed MNES Calculation N0-EE23204 “US-APWR Standard Design – Emergency Feedwater Pump Area HVAC System Calculations.” The staff concluded from the audit that the applicant’s engineering approach and calculations were sufficient. During the audit of Calculation N0 EE23204 Revision 1 the staff noted that the applicant derived the cooling requirements for the Turbine Driven EFW pump area by two different methods in different sections of the calculation. The results from each derivation differed by 2,000 Btu/hr. The staff observed that DCD Table 9.4.5-1 for the EFW Pump (T/D) Area AHU cooling coil lists the cooling coil capacity as 60,000 Btu/hr and asked the applicant why the less conservative “alternate calculation” value from the calculation appeared in DCD Table 9.4.5 1. The applicant acknowledged that 62,000 Btu/hr should appear in DCD Table 9.4.5 1 for the EFW Pump (T/D) Area AHU and agreed to revise the DCD accordingly. During the audit the staff also noted that calculations N0 EE23203, N0 EE23204 and N0 EE23205 serve as the bases of safety-related parameters and values found in the DCD Section 9.4.5. The staff requested that the applicant include these calculations as References in DCD Subsection 9.4.8. To bring to closure these issues, the staff issued RAI 670-4773, Question 09.04.05-17.

The applicant responded on December 28, 2010 (ML110040148), that Technical Report "Safety Related Air Conditioning, Heating, Cooling, and Ventilation Systems Calculations" (MUAP 10020) includes the content of Calculation N0 EE23203, N0 EE23204 and N0 EE23205. The applicant proposed to add technical report as a reference in DCD Subsection 9.4.8. The applicant also provided an amendment to Table 9.4.5-1 that would change the cooling coil capacity of EFW Pump (T/D) Area AHU from 60,000 Btu/hr to 62,000 Btu/hr. The staff found the applicant’s response to RAI 670-4773, Question 09.04.05-17 acceptable since it provided a path for closure of the audit issues. The staff verified that Revision 3 of the DCD contained both changes **and closed RAI 64-735, Question 09.04.05-01, Part 22; RAI 356-2549, Question 09.04.05-9; and RAI 670-4773, Question 09.04.05-17.**

With the issuance of Revision 2 to the DCD, the applicant added two AHUs (VRS- MAH-561A-S and VRS-MAH-561B-S) to the scope of included equipment contained in the safety-related component area HVAC system. The applicant amended the DCD to reflect this equipment addition and designated the equipment names as “A – Spent Fuel Pit Pump Area Air Handling Unit” and “B – Spent Fuel Pit Pump Area Air Handling Unit,” respectively.

The staff noted in RAI 583-4554, Question 09.04.05-12 that the applicant failed to amend DCD Subsection 9.4.5.2.5 and Table 9.4-1 to reflect this scope addition to the safety-related component area HVAC system. The staff noted that Figure 9.4.5-5 does not display isolation valves in the supply and exhaust lines of the AB ventilation system nor does it display radiation monitors in the A (&B) – Spent Fuel Pit Pump Areas. The staff could not find specific information about anticipated radiation dose rates for the Spent Fuel Pit Pump Areas in Chapter 12 of the DCD. The staff requested additional information as to the applicant’s reasons for not including detection or isolation in the design of the US-APWR. The staff also requested additional information about the impact of this scope addition on Table 9A-1 “US-APWR Fire Areas and Fire Zones” and on Table 9A-2 “Fire Hazard Analysis Summary”.

The applicant responded in a letter dated June 22, 2010 (ML101760191), to RAI 583-4554, Question 09.04.05-12 with a comprehensive response that included an amendment to DCD Subsections 9.4.3.2.1, 9.4.5.2.5 and Table 9.4-1. The applicant also indicated that RAI 539-4329, Question 09.04.02-4 dated April 1, 2010 (ML100960032), provides a revision to Figure 9.4.3-1 that incorporates the addition of the supply and exhaust lines from the SFP pump areas. The applicant also agreed to amend the Fire Hazard Analysis Summary (sheets 70 and 109 of 293) and the Fire Hazards Analysis Results for FA2-128 "B – Spent Fuel Pit Pump Room" and FA2-209 "A – Spent Fuel Pit Pump Room", respectively. The staff verified that Revision 3 of the DCD contained all the changes listed above. The applicant's response provided concise changes to the DCD that resolved all the staff identified concerns of RAI 583-4554, Question 09.04.05-12. Based on this, the staff found the applicant's response acceptable and **closed RAI 583-4554, Question 09.04.05-12.**

Revision 1 of DCD Section 9.4.5.2.2 indicated the volume of air exhausted from the battery rooms (Class 1E electrical room HVAC system) is sufficient to maintain the hydrogen concentration well below two percent. The staff notes that the applicant created ITAAC line Item 4.c of Tier 1 Table 2.7.5.2-3 to demonstrate that the hydrogen levels within the as built Class 1E battery rooms remain below two percent by volume. This use of this regulatory tool is an acceptable way to demonstrate the capability of a safety system.

In RAI 64 735, Question 09.04.05-1, Part 4, the staff requested that the applicant provide the calculation procedures and methods, including assumptions and margins, which support maintaining the hydrogen concentration below two percent by volume for the battery rooms.

In its response of October 06, 2008 (ML082830021), the applicant provided a basic formula in part from IEEE Std 484TM – 2002 with no US-APWR plant specific design data for calculating the necessary ventilation airflow for the Class 1E battery rooms. The staff could not make a regulatory finding and found applicant's response insufficient.

In followup RAI 356-2549, Question 09.04.05-4, the staff requested that the applicant redress its response to RAI 9.4.5-4 with more detail to allow the staff to complete its DCD review requirements. The applicant responded in a letter dated July 17, 2009 (ML092030375), by providing plant specific design data and using the data in an equation from British Standard BS EN 50272 2:2001.

The staff evaluated the response and found that the two equations invoked in the original RAI response and in the response to RAI 356-2549, Question 09.04.05-4 (EN 50272 2: 2001 and IEEE Standard 484: 2002) are nearly identical except for the safety factor of five used in EN 50272 2. The staff elected to perform a formal audit from May 24 - 28, 2010 (ML110800203), of the applicant's engineering calculations.

Based on audit observations the staff issued RAI 670-4773, Questions 09.04.05-14 and 09.04.05-15:

In RAI 670-4773, Question 09.04.05-14, the staff noted to the applicant that a review of DCD Table 8.3.2-3 for the Class 1E DC Power System leads to the conclusion that 60 flooded lead acid cells exist for each of the four Class 1E Battery rooms displayed on Figure 9.4.5-2 of the DCD. Review of Figure 8.3.2-1 "DC Power Distribution System (Sheet 1 of 2) Class 1E" leads to this same conclusion. In contrast, the staff noted to the applicant that 120 cells were listed in Calculation N0 EE23202 to derive the ventilation flow value requirement for each battery room to limit hydrogen concentrations at or below 1 percent by volume. The applicant clarified that

120 flooded lead acid cells exist in each of the four battery rooms and agreed to revise Table 8.3.2-3 and Figure 8.3.2-1 to reflect this fact. The staff issued RAI 670-4773, Question 09.04.05-14 to track these needed DCD changes.

In its response dated December 28, 2010 (ML110040148), to Question 09.04.05-14, the applicant indicated its intent to add as a reference to DCD subsection 9.4.8 the Technical Report "Safety Related Air Conditioning, Heating, Cooling, and Ventilation Systems Calculations" (MUAP 10020) which includes the content of Calculation NO EE23202. The staff confirmed that DCD Revision 3 contained the required changes to Table 8.3.2-3 and Figure 8.3.2-1. The staff verified that the applicant added the technical report as reference 9.4.8-30. Based on the above completed actions, the staff found the applicant's response to Question 09.04.05-14 acceptable and **closed RAI 670-4773, Question 09.04.05-14.**

In RAI 670-4773, Question 09.04.05-15, the staff documented from the staff's audit of Calculation N0 EE23202 Revision 1 that the applicant used British Standard BS EN 50272 2:2001 in its derivation of the required ventilation flow rate to keep hydrogen levels below one percent by volume within each Class 1E battery room. The staff noted that Revision 2 DCD Table 8.1 1 “Design Criteria and Guidelines for Electric Power Systems (Sheet 4 of 7)” indicated that the US-APWR conforms with RG 1.128 “Installation Design and Installation of Vented Lead Acid Storage Batteries for Nuclear Power Plants” and that RG 1.128 endorsed the use of IEEE Std 484-2002 but not BS EN 50272 2:2001. The staff requested that the applicant provide an evaluation of how the use of BS EN 50272 2:2001 provides an acceptable alternative to IEEE Std 484-2002. The staff also requested that the applicant change the DCD throughout to reflect the more conservative 1 percent (i.e. from two percent) as the limiting value for hydrogen concentration by volume within the 1E Class Battery Rooms.

In its response to RAI 670-4773, Question 09.05.05-15 dated December 28, 2010 (ML110040148), the applicant replied that the installation of the Class 1E batteries and the design of the Class 1E Electrical Room HVAC System as described in the DCD do not propose alternative acceptance criteria to SRP 8.3.2 or SRP 9.4.5 for the battery room exhaust ventilation system. RG 1.128 and IEEE Std. 484, referenced in SRP 8.3.2, do not provide the methodology to be used to calculate battery room exhaust airflow rate.

The maximum hydrogen evolution rate provided in IEEE Std. 484, Section 5.4, is used as input to the design basis calculation of required minimum battery room exhaust ventilation airflow rate. Since further details or guidance for calculation of the minimum ventilation requirement is not described in RG 1.128 or IEEE Std. 484, compliance with NRC regulations is accomplished by using the IEEE Std. 484 hydrogen evolution rate as input to the calculation, and by providing reference to RG 1.128 and IEEE Std. 484 in the DCD (References 8.3.2-6 and 8.3.2-3, respectively).

The minimum exhaust ventilation flowrate required to maintain hydrogen levels below one percent by volume within each Class 1E battery room is calculated using the equation shown in British Standard EN 50272 2:2001, Section 8.2. The equation represents a standard industry approach to convert hydrogen evolution rate per cell per charging ampere to total hydrogen evolution per battery, and find the total dilution flowrate to maintain a specified concentration by volume. This approach is consistent with the methods recommended by battery manufacturer literature and industry references. The British Standard EN 50272 2:2001 provides a typical boost charge current value that is used in the absence of specific battery manufacturer information, since the Class 1E batteries have not been procured at this time. The EN 50272 2 correlation includes a safety factor (multiplier) of 5.

British Standard EN 50272 2:2001 is included as a reference to Technical Report "Safety Related Air Conditioning, Heating, Cooling, and Ventilation Systems Calculations" (MUAP 10020). MUAP-10020 has been added at Reference 9.4.8-30 in Revision 3 of the DCD.

The staff found the applicant's response of December 28, 2010, to RAI 670-4773, Question 09.04.05-15 acceptable as it adequately explained how the DCD conforms to RG 1.128, SRP 8.3.2 and SRP 9.4.5. In addition, the staff found that the addition of Technical Report MUAP-10020 as a reference to the DCD provides an acceptable way of linking the use of British Standard EN 50272 2:2001 to the DCD Revision 3 Tier I ITAAC Table 2.7.5.2-3 "Acceptance Criteria" 4.c of maintaining the battery room hydrogen concentration below one percent by battery room volume. The staff also confirmed that the originally invoked two percent criterion has been removed from all applicable Chapter 9 and Chapter 14 sections in Revision 3 of the DCD. Based on the foregoing, the staff **closed RAI 670-4773, Question 09.04.05-15.**

The above actions allowed the staff to **close** the interrelated issues of **RAI 64-735, Question 09.04.05-1, Part 4; RAI 356-2549, Question 09.04.05-4; RAI 670-4773, Question 09.04.05-14; and RAI 670-4773, Question 09.04.05-15.**

Based on the staff's review of Revision 3 of the DCD, the foregoing RAI exchanges and DCD enhancements, the staff concluded that the engineered safety features ventilation system as described in the US-APWR DCD satisfies the requirements of GDC 4.

General Design Criterion 5

The staff reviewed the ESF ventilation system to ensure that the design satisfied the relevant requirements of GDC 5. Since the design application is for a single unit plant, GDC 5 does not apply to the ESF ventilation system.

General Design Criterion 17

The staff reviewed the ESF ventilation system to ensure that the design satisfied the relevant requirements of GDC 17. In particular, the staff reviewed the Class 1E electrical room HVAC system against the requirements of GDC 17 and NUREG CR/0660.

The staff found that DCD Section 9.4.5 failed to address how the requirements of GDC 17 and NUREG –CR/0660 were satisfied for the essential electrical components of the ESF ventilation system. In RAI 64-735, Question 09.04.05-01, Part 7 the staff requested clarification of how the system design provided for the protection of essential electrical components from failure due to the accumulation of dust and particulate materials. The applicant responded in a letter dated October 06, 2008 (ML082830021), that the essential electrical components (such as contacts and relays) of the ESF ventilation system are protected from the accumulation of dust and particulate materials by enclosing the contacts and relays in dust tight cabinets and taking outdoor ventilation air through the air filters from a height of at least seven meters (20 feet) above ground level.

The staff found the applicant's approach acceptable since the DCD as amended reflects the requirements of GDC 17 and NUREG-CR/0660. The staff verified that Revision 3 DCD subsection 9.4.5.1.1 "Safety Design Bases" included the appropriate changes. Based on this, the staff **closed RAI 64-735, Question 09.04.05-01, Part 7.**

Based on the staff's review of Revision 3 of the DCD, the foregoing RAI exchange and DCD enhancements, the staff concluded that the ESF ventilation system as described in the US-APWR DCD satisfies the requirements of GDC 17.

General Design Criterion 60

The staff reviewed the ESF ventilation system to ensure that the design satisfied the relevant requirements of GDC 60. The staff's review ensured that the system is capable of suitably controlling release of gaseous radioactive effluents to the environment by meeting the requirements of RG 1.52 and RG 1.140 as related to design, inspection, and testing of air filtration and iodine adsorption units of ESF atmosphere cleanup systems in light water cooled nuclear power plants.

The staff reviewed the ESF ventilation system to ensure that the design satisfied the relevant requirements of review interface 9 to SRP Section 9.4.5. In particular, the staff reviewed the design of the annulus emergency exhaust system to ensure the effectiveness of the ESF ventilation system filters in removing airborne contaminants before discharge to the environment.

Sheet 3 of 3 of DCD Table 9.4.5-1, "Equipment Design Data," provides data for the annulus emergency filtration unit and charging pump area AHUs of the safety-related component area HVAC system. The information contained in the table identified a cooling coil capacity of 4,000 Btuh and 6,000 Btuh, respectively for each AHU. DCD Figure 9.4.5-5 (sheet 2 of 2) identified two cooling coils per AHU consistent with Figure 9.2.7-1, "Essential Chilled Water System Flow Diagram." The staff found that it was unclear how to interpret the cooling capacity of the four AHUs displayed on DCD Figure 9.4.5-5. In RAI 64-735, Question 09.04.05-01, Part 12, the staff asked the applicant whether the total cooling capacity of these four AHUs was 4,000 Btu/hr and 6,000 Btu/hr (respectively) OR 8,000 Btu/hr and 12,000 Btu/hr (respectively).

After several RAI exchanges, the applicant responded in a letter dated July 17, 2009 (ML092030375), with a revision to DCD Subsection 9.4.5.2.5 and Table 9.4.5-1 with changes that adequately explained the system's configuration and removed all areas of conflict. The staff confirmed that the applicant incorporated these changes into Revision 3 of the DCD. The staff found that the applicant had provided a comprehensive resolution to all four issues presented in RAI 356-2549, Question 09.04.05-8. Based on this, the staff found the applicant's response acceptable and **closed RAI 64-735, Question 09.04.05-01, Part 12 and RAI 356-2549, Question 09.04.05-8.**

In RAI 64-735, Question 09.04.05-01, Part 9, the staff requested that the applicant provide additional information regarding how only HEPA filters (i.e., no carbon absorbers) in the annulus emergency exhaust filtration unit during the ESF mode meet the limits specified in 10 CFR Part 20. After a series of RAI exchanges dated October 06, 2008, and July 17, 2009, (ML082830021 and ML092030375), the applicant agreed to revise DCD Subsections 9.4.5 and 9.4.5.2.1 to adequately explain the design of annulus emergency exhaust system and to revise Section 9.4.5.2.1 to include the justification for excluding a charcoal adsorber.

The staff found the applicant's approach acceptable in that the changes to Revision 3 of the DCD adequately explain how the annulus emergency exhaust filtration unit during the ESF mode meets the limits specified in 10 CFR Part 20 without charcoal adsorbers. Based on this, the staff **closed RAI 64-735, Question 09.04.05-01, Part 9.**

The staff noted that Figures 9.4.5 1 and 9.4.5 3 display the system isolation dampers from the AB HVAC system, which interfaces with the ESF ventilation system. While the operation of the isolation dampers for the safeguard component area HVAC system (Figure 9.4.5 3) is described in DCD Section 9.4.5.1.1.3, the operation of the isolation dampers for the four penetration areas of Figure 9.4.5 1 are not described in DCD Section 9.4.5.1.1.5. In RAI 64-735, Question 09.04.05-01, Part 20, the staff requested that the applicant describe in the DCD Section 9.4.5.1.1.5 the transfer of these isolation dampers from normal to emergency mode of operation.

The applicant responded in a letter dated October 06, 2008 (ML082830021), with a DCD amendment that added a description of the operation of the isolation dampers for four penetration areas to DCD Section 9.4.5.1.1.1. The applicant further explained that the isolation dampers for the four penetration areas of Figure 9.4.5-1 are automatically closed to isolate from the AB HVAC system and to maintain a negative pressure in the penetration area upon receipt of an ECCS actuation signal. The staff verified that Revision 3 DCD Subsection 9.4.5.1.1.1 included the amendment. The staff found that this change resolved the issue presented in RAI 64-735, Question 09.04.05-01, Part 20. The staff found the response acceptable since a description in the DCD of the transfer of these isolation dampers from normal to emergency mode of operation is fundamental to GDC 60 conformance. Based on this, the staff **closed RAI 64 -735, Question 09.04.05-01, Part 20.**

The standards employed in the design of the US-APWR were the subject of RAI 442-3378, Question 09.04.01-10. Specifically the staff questioned the use of a more recent version of ASME AG-1 than had been endorsed by the staff. The applicant responded to RAI 442-3378, Question 09.04.01-10 with two RAI responses on September 18, 2009, and December 09, 2009, (ML092650173 and ML093480146) that made a comparison of the approved version versus the newer version. The results of the review were provided in a table. The applicant concluded that the use of the 2003 edition of the Code, rather than the 1997 edition referenced in the NRC guidance documents, is justified. The staff conducted an independent side by side comparison of the two AG-1 Codes to confirm that the use of ASME AG-1 2003 edition is an acceptable alternative to ASME AG-1 1997 for the MCR HVAC system design and testing. For the substantive areas of difference the applicant provided a comprehensive technical justification (as applicable) for the use of AG-1 2003 and AG-1a 2000, in lieu of AG-1 1997, in the design of the US-APWR DCD ventilation subsections. Based on this review the staff concluded that the applicant has provided sufficient justification to demonstrate that the proposed alternatives to the SRP 9.4.5 “Acceptance Criteria” for RG 1.52 provide acceptable methods of compliance with the NRC regulations. Based on this finding the staff **closed both RAI 442-3378, Question 9.4.1-10 and RAI 484-3850, Question 09.04.01-15.**

Based on the staff’s review of Revision 3 of the DCD, the foregoing RAI exchange and DCD enhancements, the staff concluded that the ESF ventilation system as described in the US-APWR DCD satisfies the requirements of GDC 60.

10 CFR 50.48 Fire Protection

The staff reviewed the ESF ventilation system to ensure that the system design satisfies the relevant requirements for fire protection as stipulated per 10 CFR 50.48. Fire Protection requirements are comprehensively addressed in Section 9.5 of this SER.

In RAI 64-735, Question 09.04.05-01, Part 15 the staff noted that DCD Section 9.4.5.3.2, "Class 1E Electrical Room HVAC System" states that all duct penetrations in fire walls are protected by fire dampers to prevent the spread of fire from the affected area to the adjacent redundant component areas. The staff found no mention of this fire protection attribute for the ESF areas served in the safety design basis section for any of the other four ESF ventilation system. In addition, the staff noted that DCD Section 9.4.3, "Auxiliary Building Ventilation System," did not indicate that this fire protection attribute will be installed in the ductwork for these same ESF areas served. The staff also noted that DCD Section 9.4.5.2.2.2, "Smoke Purge Mode," (i.e., for the Class 1E electrical room HVAC system) did not contain any information on system response in the event of smoke or fire. The staff requested that the applicant include a discussion of the fire protection attributes as described in DCD Section 9.5.1.2.7 for all ESF ventilation systems of DCD Section 9.4.5.

The applicant's response of October 06, 2008 (ML082830021), included an amendment to the DCD that would incorporate into the DCD the fire protection attributes for all ESF ventilation systems of DCD Section 9.4.5. The staff evaluated the changes in Revision 3 of the DCD as compliant with 10 CFR 50.48 requirements. Based on this review, the staff found the applicant's response acceptable. Accordingly, the staff **closed RAI 64-735, Question 09.04.05-01, Part 15.**

10 CFR 50.63 Loss of all alternating current power

The staff reviewed the ESF ventilation system to ensure that the system design satisfies the relevant requirements for SBO as stipulated per 10 CFR 50.63.

The staff reviewed the ESF ventilation system to ensure that the applicant satisfied the relevant requirements of RG 1.155 Position C.3.2.4. The ESF ventilation system was reviewed to ensure that:

(1) portions of the system have been designed so that system function will be performed as required in the event of a SBO;

(2) the ESF ventilation system has sufficient capacity and capability to maintain a suitable environment for the duration of a station blackout event and the associated recovery period; and

(3) failure of non required portions of the ESF ventilation system will not adversely affect the functioning of required equipment.

The SBO requirements are comprehensively addressed in Section 8.4 of this SER. Appropriate instrumentation and electrical equipment limits will be addressed in SER Chapters 7 and 8.

The staff elected to perform a formal audit from May 24 - 28, 2010 (ML110800203), of the applicant's engineering calculations. Based on audit observations the staff issued RAI 670-4773, Questions 09.04.05-18 where it was noted that during the staff's audit of Calculation N0 EE23202, Revision 1 that the applicant used British Standard BS EN 50272 2:2001 in its derivation of the required ventilation flow rate to keep hydrogen levels below one percent by volume within each Class 1E battery room. Section 8.1 of this British Standard reads "When the operation of the charge equipment is stopped the emission of gas from the cells can be regarded as having come to an end one hour after having switched off the charging current." The staff observed that this information contradicts MHI's response to RAI 64-735, RAI 9.4.5-18 b) which reads "The hydrogen concentration would not change following a SBO. The batteries do not generate hydrogen except when being charged and would not be charging during this period."

During the audit, the applicant responded that during the one hour after the start of the SBO event, the battery banks would be discharging (i.e. not sitting idle) and that during this transitional state no hydrogen gas would be generated.

In RAI 670-4773, Question 09.04.05-18, the staff requested that the applicant amend the response to RAI 64-735, RAI 9.4.5-18 b) to remove the contradiction and to provide the basis for the applicant's audit response.

The applicant responded on December 28, 2010 (ML110040148):

> "Batteries generate hydrogen during charging mode, and do not generate hydrogen during discharging mode. Hydrogen generation from batteries will stop due to battery discharge regardless of discharge rate. In SBO condition, the batteries keep discharging until recharging by AAC power source. Therefore, the battery room ventilation fans do not need to operate until recharging by AAC power source after SBO occurs."

The applicant agreed to amend its response to RAI 64-735 (ML082830021), Question 9.4.5-18. The staff assessed applicant's response against Section 8.1 of British Standard BS EN 50272-2:2001. Since the British Standard describes a static situation (i.e. neither charging nor discharging) the staff acknowledged the applicant's technical response as acceptable. The staff will hold **RAI 670-4773, Question 09.04.05-18 as Confirmatory Item 09.04.05-18** until the response to RAI 64-735, RAI 9.4.5-18 is corrected.

SRP 9.4.5 Section I.3 directs the review of the ESF ventilation system to ensure suitable environments are maintained in areas containing equipment required to function during a SBO. The staff requested in RAI 64-735, Question 09.04.05-01, RAI 9.4.5-18 the following information related to SBO from the applicant:

a) Provide the minimum/maximum temperatures and/or humidity values for the Class 1E battery room with respect to SBO in DCD Table 9.4-1 (sheet 1 of 3).

b) What happens to the hydrogen concentrations within the Class 1E battery room during the 60 minutes it takes to load the AAC with Table 8.3.1-6, "Electrical Load Distribution. AAC GTG Loading (SBO Condition)"?

c) Do the abnormal condition temperatures of DCD Table 9.4-1 for the areas ventilated by the Class 1E electrical room HVAC system bound the area temperatures expected in these areas for the entire duration of the eight hour coping event?

The applicant responded in a letter dated October 06, 2008 (ML082830021), that in the case of the SBO, the AAC GTGs start automatically. One hour is allotted to manually align an available AAC GTG with a Class 1E bus that provides power to the Class 1E electrical room HVAC system AHUs. This system serves the Class 1E battery and electrical rooms, as well as other areas. Also during this one hour period of the SBO, no equipment is operating in the Class 1E electrical room as no power source is available; hence no heat load generation, except perhaps emergency lighting.

a) Table 9.4-1 indicates the design parameters when the HVAC equipment is in operation. It is not intended to indicate room conditions following a loss of ventilation that would occur with an SBO event.

b) The hydrogen concentration would not change following an SBO. The batteries do not generate hydrogen except when being charged and would not be charging during this period.

c) The Class 1E electrical room HVAC system is available within 60 minutes (one hour), per Section 8.4.2.1.2 of the DCD. The temperatures shown in Table 9.4-1 for abnormal conditions for the Class 1E electrical room are expected to bound those encountered during the short duration of the SBO. Because there is no electrical power source for the equipment in the room, no heat load is generated. The only heat load experienced in the room will come from emergency lighting and any heat generated by the equipment (up to the moment of the SBO event) having residual effects. The heat load is expected to be negligible and short lived, especially in the presence of the large mass of the walls that will act as heat sinks.

The staff reviewed the response and found that the applicant adequately addressed the staff's RAI with one exception. The responses were acceptable because the Acceptance Criteria of ITAAC Table 2.6.5-1 Item 12 ensure through testing and analysis the reliability and capability of an as built AAC power source [i.e. reference RAI 582-4456 Question 09.04.01-20 dated July 16, 2010 (ML102010040)]. Item 12 provides reasonable assurance that the Class 1E electrical room HVAC system will be available within 60 minutes from the onset of SBO. With regard to the issue of hydrogen production, the staff found the applicant's response acceptable. Further discussion of this issue is captured in RAI 670-4773, Question 09.04.05-18 (above). Based on this, the staff found the response acceptable for a) and c) and closed RAI 64-735, Question 09.04.05-01, Part 18. The staff notes that Revision 3 of the US-APWR DCD Tier 1 deleted Item 12 from Table 2.6.5-1. This is a new **open item.** The staff issued **RAI 825-5999, Question 09.04.05-22**, **Open Item 09.04.05-22** to determine the applicant's basis for the deletion of Item 12 from US- APWR DCD Tier 1 Table 2.6.5 1.

<u>10 CFR 52.47(b)(1) – Inspections, Test, Analyses, And Acceptance Criteria</u>

The staff reviewed the ESF ventilation system to ensure that the applicant satisfied the relevant the regulatory requirements contained in 10 CFR 52.47(b)(1). These are partially addressed by the staff in this section of the SER and are further addressed in DCD Section 14.3.7, Plant Systems – Inspections, Tests, Analyses, and Acceptance Criteria.

The staff requested in RAI 64-735, Question 09.04.05-1, Part 1, that the applicant provide additional details about the calculation procedures and methods, including assumptions and margins used in the design of the four heating/cooling subsystems of the ESF ventilation system. The applicant responded in a letter dated October 06, 2008 (ML082830021), that DCD Section 9.4.5, Table 9.4-1 shows the design parameter on the temperature and relative humidity of each room; and indicated that these values were not the result of calculation. The design values of the system were based on the Utility Requirements Document, requirements from the instrumentation and control system, and the experience of Japanese PWR plants.

Based on the additional information provided, the staff could not complete its regulatory review of SRP 9.4.5 “Areas of Review,” Section I.2. Therefore the staff found the applicant’s response insufficient. The staff issued followup RAI 356-2549, Question 09.04.05-2.

The applicant responded in a letter dated July 17, 2009 (ML092030375), that the intention of its response to RAI 9.4.5-1 was that Table 9.4-1 sets the design condition used to determine the capacity of the HVAC system. The ITAAC for the ESF ventilation system is addressed in DCD Tier 1 Table 2.7.5.2-3. The applicant provided a revision to this table to demonstrate the ability of the ESF heating and cooling subsystems to maintain a suitable ambient temperature range in the areas serviced. The applicant referred the staff to RAI 184-1912, Question 14.03.07-26 (ML091040177) which includes individual ITAAC to verify the ESF ventilation system subsystems are capable of maintaining area temperatures within design limits. The applicant chose to verify the heat loads and cooling coil capacity using ITAAC. These regulatory tools are acceptable ways to demonstrate the capability of safety systems and the staff finds the applicant’s approach acceptable.

After evaluating the response to RAI 184-1912, Question 14.03.07-26, the staff requested in RAI 474-3811, Question 09.04.05-10, that the applicant expand the operational scope and provide more precise definition to items 4.b through 4.f of Tier 1, Table 2.7.5.2-3. All of these items pertain to the subsystems of the ESF ventilation system.

The applicant concluded its response of November 13, 2009 (ML093210470), with a revision to ITAAC Items 4.b through 4.f of Tier 1 Table 2.7.5.2-3 that detailed changes that would fully resolve the staff concerns as documented RAI 474-3811, Question 09.04.05-10. Based on the DCD’s use of ITAAC to verify the correct sizing of the heating and cooling subsystems of the ESF ventilation system, the staff found the response to RAI 474-3811, Question 09.04.05-10 acceptable. Revision 3 of the DCD did not reflect the changes to ITAAC Table 2.7.5.2-3 Item 4.b as detailed in the applicant’s response of November 13, 2009 to RAI 474-3811, Question 09.04.05-10. Instead, revision 3 of Tier 1 Table 2.7.5.2-3 Item 4.b refers to the rooms described in Tier 1 Subsection 2.7.5.2.1.2 and fails to list in the subsection: (a) the CRDM Panel Room, (b) the M G Set and M G Set Panel Room, (c) the Leak Rate Testing Room, (d) the Reactor Trip Breaker Room, and (e) the AAC Selector Circuit Panel Room and (f) the humidity limits of the Remote Shutdown Console Room. Accordingly, the staff holds as an **open item, the RAI series – RAI 64-735, Question 09.04.05-1, Part 1; RAI 356-2549, Question 09.04.05-2; RAI 474-3811, Question 09.04.05-10 and RAI 825-5999, Question 09.04.05-20.** The staff issued **RAI 825-5999, Question 09.04.05-20** , **Open Item 09.04.05-20** to request that the applicant revise ITAAC Table 2.7.5.2-3 Item 4.b and/or Subsection 2.7.5.2.1.2 to reflect the changes detailed in RAI 474-3811, Question 09.04.05-10.

The staff reviewed the ESF ventilation system to ensure that the system design satisfied the relevant requirements of RG 1.206 Position C.I.9.4.5.4. The staff reviewed the inspection and testing programs to ensure the ESF ventilation system will meet its functional requirements, including those that will be controlled through technical surveillance. The inspection and testing programs are addressed in SER Section 14.3.7. TS are addressed in SER Chapter 16.

Consistent with SRP 9.4.5, review interface 16, the staff reviewed the ESF ventilation system proposed TS to ensure TS 3.7.11 parallels to the extent possible the TS 3.7.14 of the Standard TS Westinghouse Plants, NUREG 1431, Volume 1 Revision 3.

The regulatory requirements of 10 CFR 52.47 state that the application must contain a level of design information sufficient to enable the Commission to judge the applicant's proposed means of assuring that construction conforms to the design and to reach a final conclusion on all safety questions associated with the design before the certification is granted. The information submitted for a DC must include performance requirements and design information sufficiently detailed to permit the preparation of acceptance and inspection requirements by the NRC, and procurement specifications and construction and installation specifications by an applicant. The staff noted in RAI 64-735, Question 09.04.05-01, Part 6 and its followup RAI 356-2549, Question 09.04.05-5 that DCD Section 9.4.5.4 needed more information.

The applicant responded in a letter dated October 06, 2008, and July 17, 2009, (ML082830021 and ML092030375) by adding a detailed list of the specific standards required to satisfy the testing and inspection requirements for the ESF ventilation system to DCD Section 9.4.8. The staff found the applicant's final resolution acceptable in that Revision 3 DCD Subsection 9.4.5.4 now satisfies the regulatory requirements of 10 CFR 52.47. Based on this, the staff closed RAI 64- 735, Question 09.04.05-01, Part 6 and RAI 356-2549, Question 09.04.05-5.

DCD Section 9.4.5.2.1 indicates the annulus emergency exhaust system draws down the penetration and safeguarded component areas to a negative pressure of 0.25 in. w.g. with regard to adjacent areas. In RAI 64-735, Question 09.04.05-1, RAI 9.4.5-3, pursuant to the review guidance of SRP 9.4.5 Section III.1 the staff requested that the applicant provide calculation procedures and methods, including assumptions and margins, to support maintaining a negative pressure of 0.25 in. w.g.

The applicant responded in a letter dated October 06, 2008, (ML082830021) by providing two formulas with a supporting calculation that derived the required airflow rates for the penetration areas and the safeguard component areas of the plant. The derived value from this calculation for the airflow rate of the annulus emergency exhaust filtration unit fan equals 5,600 ft^3/min. This is consistent with the value found in Table 9.5.4-1 for the annulus emergency exhaust filtration unit. The staff assessed the assumptions and parameters used in this calculation. Based on this assessment, the staff requested additional information in RAI 356-2549, Question 09.04.05-3 with five specific questions.

The applicant responded in a letter dated July 17, 2009 (ML092030375), with a detailed answer to all five questions. The staff noted that the calculations employed were more understandable and logical than in the original RAI response. However, the calculations still lacked the clarity of assumptions and sources of information for the parameters used that a formal engineering calculation would contain. This left the staff with more unanswered questions. Based on this the staff conducted a formal audit from May 24 - 28, 2010 (ML110800203), of the applicant's engineering calculations.

The staff concluded from the audit that the applicant's engineering approach and calculations were of sufficient detail that the design basis numbers in Table 9.5.4-1 for establishing and maintaining a negative pressure of 0.25 in. w.g. in the penetration and safeguarded component areas are credible.

However, based on staff observations from the audit and staff exchange with the applicant during the audit, the staff issued RAI 670-4773, Question 09.04.05-16. In this question, the staff noted that calculation N0 EH80016 clearly defined, with plant annotated figures, the Reactor Building areas that comprise the safeguard component area and the annulus area. This calculation also derived the volumes of both areas. The staff observed that the DCD does not clearly define these areas nor describe these areas in sufficient detail to evaluate the efficacy of the system. The staff emphasized the significance of boundaries in that they define the operability requirements for the annulus emergency exhaust system as specified in SR 3.7.11 B.1 (Revision 2 DCD Chapter 16, Page 3.7.11-4).

The staff requested that the applicant amend DCD Section 6.5.1 to include a description of these areas and the significance of these areas in passing the SRs associated with the AEES. The staff also requested that the applicant revise the DCD Section 6.5.1 to clearly define the drawdown areas of the safeguard component area and the annulus area.

The applicant responded in a letter dated December 28, 2010 (ML1100401480), with a revision to DCD Section 6.5.1 consistent with the staff's request. The staff verified that Revision 3 of the DCD contains the needed changes to Section 6.5.1. Section 6.5.1 has been amended and Figures 6.5-2 through 6.5-9 have been added to the DCD, to the extent necessary to clearly define the drawdown areas for Penetration Areas and the Safeguard Component Areas of SR 3.7.11 B.1.

The staff noted to the applicant during the audit's exit briefing that calculations N0 EE23201 and N0 EH80016 serve as the bases of safety-related parameters and values found in both DCD Sections 6.5.1 and 9.4.5. Accordingly, the staff also requested in RAI 670-4773, Question 09.04.05-16, that the applicant include (a) calculation N0 EE23201 "US APWR Standard Design Annulus Emergency Exhaust System (AEES) Calculations" as a Reference in DCD Subsection 9.4.8; and (b) calculation N0 EH80016 "US-APWR Standard Design Safeguard Component Area and Annulus Area Volume" as a Reference in DCD Subsection 6.5.7. The applicant responded in a letter dated December 28, 2010, that Technical Report "Safety Related Air Conditioning, Heating, Cooling, and Ventilation Systems Calculations" (MUAP 1 0020) submitted to the NRC includes the content of Calculation N0 EE23201 and will be included as a reference in DCD Subsection 6.5.7 and 9.4.8. The staff found this part of the applicant's response acceptable. However, after review of the MUAP 10020 and Revision 3 of the DCD, the staff found one commitment to change missing in the DCD. The applicant failed to amend DCD Subsection 6.5.7 with a reference to the technical report. Therefore, **RAI 64-735, Question 09.04.05-1, Part 3; RAI 356-2549, Question 09.04.05-3; and RAI 670-4773, Question 09.04.05-16 remain a Confirmatory Item 09.04.05-16** and the staff issued **RAI 825-5999, Question 09.04.05-21** to ensure the applicant is aware of the needed DCD change.

SRP 9.4.5 "Review Procedures"

The following RAIs resulted from the staff's DCD Section 9.4.5 review per the guidance of SRP 9.4.5 Section III "Review Procedures."

The staff found that DCD Figure 9.4.5-3 did not label the A, B, C, and D safeguard component areas to indicate which components are being served (i.e. containment spray; RHR pump area, safety injection pump; RHR Hx area). In RAI 64-735, Question 09.04.05-01, Part 17, the staff requested that the applicant clarify what specific components the safeguard component area HVAC system serves in DCD Figure 9.4.5-3.

The applicant responded in a letter dated October 06, 2008 (ML082830021), with revision of Figure 9.4.5-3 to: (a) identify the boundary of the ESF ventilation system and non ESF ventilation system and (b) clarify in this figure the areas served by the safeguard component area HVAC system. The staff found that Revision 3 DCD Figure 9.4.5-3 comprehensively resolved the issues documented in RAI 64-735, Question 09.04.05-01, Part 17 and now satisfies the guidance of SRP 9.4.5, Section III. Based on this, the staff found the applicant's response acceptable and **closed RAI 64-735, Question 09.04.05-01, Part 17.**

The staff found that DCD Table 9.4.5-1, "Equipment Design Data," did not list all of the components in the AHUs shown in DCD Figures 9.4.5-1, -2, -3, and -4. In RAI 64-735, Question 09.04.05-01, Part 8 the staff requested that the applicant provide additional information on the high- and low-efficiency filters used in the ESF ventilation system. The applicant responded in a letter dated October 06, 2008 (ML082830021), with a revision to Table 9.4.5-1 that included the filter efficiencies for Class 1E Electrical Room AHU, Annulus Emergency Exhaust Filtration Unit and the EFW Pump (T/D) Area AHU. The staff confirmed that the changes described in the applicant's response were incorporated in Revision 3 of the DCD. The staff found that the applicant's response to RAI 64-735, Question 09.04.05-01 reconciled the DCD to the guidance of SRP 9.4.5, Section III for the subject components and is therefore acceptable. Based on this, the staff **closed RAI 64-735, Question 09.04.05-01, Part 8**.

9.4.5.5 Combined License Information Items

The following is a list of item numbers and descriptions from Table 1.8-2 of the US-APWR DCD. The table was augmented to include "action required by COL applicant/holder."

Table 9.4.5-1
US-APWR Combined License Information Items

Item No.	Description	Section
9.4(4)	The COL applicant is to determine the capacity of cooling and heating coils that are affected by site specific conditions.	
9.4(6)	The COL applicant is to provide a system information and flow diagram of ESW pump area ventilation system if the ESW pump area requires HVAC.	

COL information items not identified in Table 1.8-2 of the US-APWR DCD:

The staff reviewed the COL information items listed in US-APWR DCD Tier 2 Section 1.8.2 and found that there are two relevant COL Items remaining in Revision 3 of DCD Section 9.4.7. The staff concluded that this is appropriate, but additional COL items with associated potential RAIs may be recommended based upon open item closeouts and the final SER technical evaluation.

9.4.5.6 Conclusion

As set forth in Sections 9.4.5.3 and 9.4.5.4 of this SER for the US-APWR ESF ventilation system, the staff reviewed along with the RAI responses and US-APWR supporting information to determine if this design adequately meets the guidance given in SRP Section 9.4.5.

Based on this review, the following two Confirmatory Items and two Open Items remain:

CONFIRMATORY ITEM -- RAI 4773, Question 09.04.05-18, Confirmatory Item 09.04.05-18.

CONFIRMATORY ITEM -- RAI 64-735, Question 09.04.05-1, Part 3 and RAI 356-2549, Question 09.04.05-3; RAI 670-4773, Question 09.04.05-16; and RAI 825-5999, Question 09.04.05-21, Confirmatory Item 09.04.05-21.

OPEN ITEM -- RAI 64-735, Question 09.04.05-1, Part 1; RAI 356-2549, Question 09.04.05-2; RAI 474-3811, Question 09.04.05-10; and RAI 825-5999, Question 09.04.05-20, Open Item 09.04.05-20.

Open item -- RAI 64-735, Question 09.04.05-01, Part 18 and RAI 825-5999, Question 09.04.05-22, Open Item 09.04.05-22.

As set forth above in Sections 9.4.5.2 and 9.4.5.3 of this report, the US-APWR ESF ventilation system has been reviewed along with the RAI responses and US-APWR supporting information to determine if this design adequately meets the guidance given in SRP Section 9.4.5. The staff concludes this section meets the guidance in SRP Section 9.4.5 subject to the open, confirmatory and COL items listed above. Accordingly, the staff concludes, with the above noted exceptions, that the application meets the relevant requirements of 10 CFR 50.63, 10 CFR 52.47(b)(1) and 10 CFR Part 50, Appendix A, GDC 2, 4, 5, 17, and 60 (and is acceptable).

9.4.6 Containment Ventilation System

9.4.6.1 Introduction

The containment ventilation system provides control and maintains the environment, temperature and radioactivity concentration within the containment at a level suitable for plant equipment operations and to allow safe access to the containment for the operating personnel during inspection and maintenance periods. The system includes safety-related and nonsafety-related portions.

9.4.6.2 Summary of Application

DCD Tier 1: The Tier 1 information associated with the containment ventilation system is found in DCD Tier 1, Section 2.7.5.3.

DCD Tier 2: The applicant has provided a Tier 2 description of the containment ventilation system in Section 9.4.6 of the US-APWR DCD, summarized here, in part, as follows:

The containment ventilation system includes the following subsystems:

- Containment purge system.
- Containment fan cooler system.
- Control rod drive mechanism (CRDM) cooling system.
- Reactor cavity cooling system.

The containment purge system consists of the low-volume purge system and the high-volume purge system. The low-volume purge system maintains acceptably low levels of radioactivity during normal plant operation. It consists of two AHUs; two exhaust filtration units, containment isolation valves, dampers, ductwork and associated instrumentation and controls. The high-volume purge system maintains acceptably low levels of radioactivity during refueling operations. It consists of one AHU and one exhaust filtration unit. Other than the safety-related containment isolation valves, the containment purge system has no other safety function.

The containment fan cooler system consists of four fan cooler units, each sized for 1/3 of the total containment heat load, dampers, ductwork and associated instrumentation and controls. The system does not serve a safety function. The CRDM cooling system is sized to remove the heat dissipated by the CRDM and transfer the heat to the non-essential chilled water system. It consists of a chilled water cooling coil, backdraft dampers, and two centrifugal fans. The system does not serve a safety function. The reactor cavity cooling system consists of two supply air fans, each sized for 100 percent capacity, a backdraft damper, ductwork and associated I&C. The system does not serve a safety function. The containment ventilation system is shown in Figure 9.4.6-1 and the equipment design data is presented in Table 9.4.6-1.

The table provides representative capacities for cooling and heating coils of the containment purge system.

ITAAC: The ITAAC associated with DCD Tier 2, Section 9.4.6 are given in DCD Tier 1, Section 2.7.5.3.

TS: The TS associated with DCD Tier 2, Section 9.4.6 are given in DCD Tier 2, Chapter 16, Section 3.3.2 “Engineered Safety Feature Actuation System (ESFAS) Instrumentation,” Section 3.6.3 “Containment Isolation Valves,” and Section 3.9.4 “Containment Penetrations.”

9.4.6.3 Regulatory Basis

There is not a specific NUREG-800 SRP that relates to the four predominately non-safety related subsystems that comprise the containment ventilation system (CVVS) of the US-APWR. The relevant requirements of the Commission’s regulations for this area of review, and the associated acceptance criteria, are given in SRP Section 9.4.3, “Auxiliary and Radwaste Area Ventilation System”, of NUREG-0800, and are summarized below. Review interfaces with other SRP sections can be found in Section 9.4.3.1 of NUREG-0800.

The staff also reviewed the applicant’s Tier 2 DCD Section 9.4.6 “Containment Ventilation System” against the guidance of SRP Section 6.5.1, “ESF Atmosphere Cleanup Systems.” The US-APWR DCD specifies the four subsystems and integral components that comprise the containment ventilation system as non-safety with one exception. This one exception pertains to the containment purge subsystem’s four sets of containment isolation valves. These valves are listed against containment penetration numbers P451, P452, P410 and P401 in DCD Table 6.2.4-3. DCD Section 9.4.6.1.1 specifies these isolation valves as Seismic Category I and safety-related.

The applicant’s containment ventilation systems are acceptable if they meet the codes and standards, and the regulatory guidance commensurate with the safety function to be performed. This will ensure that the relevant requirements of GDC 2, 5, 41, 42, 43, 60, 61 and 64 are met. These requirements are discussed below.

1. GDC 2, "Design Bases for Protection Against Natural Phenomena," as related to the system and its components important to safety being capable of withstanding the effects of natural phenomena such as earthquakes, tornados, hurricanes, floods, tsunami, and sieches without loss of capability to perform their safety functions.

2. GDC 5, "Sharing of Structures, Systems, and Components," as related to shared systems and components important to safety.

3. GDC 41, “Containment Atmosphere Cleanup,” as it relates to providing systems to control the release of fission products to the environment and to control the concentration of hydrogen, oxygen, and other substances in containment following postulated accidents.

4. GDC 42, “Inspection of Containment Atmosphere Cleanup,” as it relates to designing containment ESF atmosphere cleanup systems to permit inspection.

5. GDC 43, “Testing of Containment Atmosphere Cleanup Systems,” as it relates to designing containment ESF atmosphere cleanup systems to permit pressure and functional testing.

6. GDC 60, "Control of Release of Radioactive Materials to the Environment," as related to the systems capability to suitably control release of gaseous radioactive effluents to the environment.

7. GDC 61, “Control of Release of Radioactive Material to the Environment,” as it relates to the design of systems for radioactivity control under normal and postulated accident conditions.

8. GDC 64, “Monitoring Radioactivity Releases,” as it relates to monitoring releases of radioactivity from normal operations, including AOOs, and from postulated accidents.

9. 10 CFR 52.47(b) (1), which requires that a DC 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 facility 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.

Acceptance criteria adequate to meet the above requirements are:

1. For GDC 2, acceptance is based on the guidance of RG 1.29, Position C.1 for safety-related portions, and Position C.2 for nonsafety-related portions.

2. For GDC 5, acceptance is based on the determination that the use of the ABVS in multiple-unit plants during an accident in one unit does not significantly affect the capability to conduct a safe and orderly shutdown and cooldown in the remaining unit(s).

3. For GDC 60, acceptance is based on the guidance of RG 1.52 and RG 1.140, as related to design, inspection, testing, and maintenance criteria for post-accident and normal atmosphere cleanup systems, ventilation exhaust systems, air filtration, and adsorption units. For RG 1.52, Rev. 2, the applicable regulatory position is C.3. For RG 1.140, Revision 1, the applicable regulatory positions are C.1 and C.2. For RG 1.140, Revision 2, the applicable regulatory positions are C.2 and C.3.

9.4.6.4 Technical Evaluation

US-APWR FSAR Section 9.4.6 "Containment Ventilation System (CVVS)" provides four functions during normal power operations and refueling operations: (1) in-containment recirculation and cooling; (2) CRDM cooling; (3) reactor cavity cooling; and (4) containment low-volume and high-volume purge. The CVVS contains two redundant purge-exhaust filtration units in the containment low-volume purge system and one purge-exhaust filtration unit in the containment high-volume purge system. The containment ventilation system is classified as a nonsafety-related system.

The only portions of the system that are safety-related Seismic Category I are the eight containment penetration isolation valves that are part of the flow path for the containment low-volume purge system and containment high volume purge system.

In RAI 73-943, Revision 0 (ML083030089) the staff submitted twenty questions that pertained to the applicable GDC of 10 CFR 50, Appendix A and other areas of DCD Section 9.4.6 that required clarification and/or DCD amplification. What follows is a synopsis of the questions related to plant safety and the applicant's response.

9.4.6.4.1 GDC 2, "Design Bases for Protection Against Natural Phenomena"

The staff reviewed the containment ventilation system against the relevant requirements of GDC 2. The staff reviewed the four subsystems that comprise the containment ventilation system, to ensure that the system is capable of withstanding the effects of natural phenomena by meeting the guidelines of RG 1.29, "Seismic Design Classification," Position C.1 for safety-related portions of the system and Position C.2 for nonsafety-related portions of the system. With RAI 73-943, Question 06.05.01-1, Part 6 the staff noted many inconsistencies in the DCD with respect to 10 CFR 50 Appendix A GDC 2 and RG 1.29 classifications of SSCs for the containment ventilation system. In particular, the staff identified seismic class labeling errors, conflicts and/or inconsistencies in DCD Subsections 9.4.6.1, 9.4.6.3.1, 9.4.6.3.2 and 9.4.6.3.3 and Table 3.2-2. The staff requested that the applicant revise the DCD to remove these errors, conflicts and/or inconsistencies. The staff also requested that the applicant include a detailed discussion in Section 9.4.6 of how the design of the containment ventilation system satisfies the guidance of RG 1.29 and GDC 2. The staff also noted that Tier 1 Section 2.7.5.3 "Containment Ventilation System (CVVS)" indicates for each CVVS subsystem under the attribute of "Seismic and ASME Code Classifications" each subsystem is "non seismic category." The staff asked the applicant to re-evaluate these attributes based on resolution of the errors, conflicts and/or inconsistencies identified in the Tier 2 subsections and Table.

In its response dated October 24, 2008 (ML083030089), the applicant acknowledged the staff's observations and agreed to amend the DCD to remove the deficiencies. The staff verified that Revision 2 of the DCD as amended resolved the staff's documented concerns of RAI 73-943, Question 06.05.01-1, Part 6. The amendments to Tier 1 subsection and to Tier 2 subsections and table cited above removed the errors, conflicts and inconsistencies noted. Since these amendments demonstrate compliance with GDC 2, the staff found the applicant's approach acceptable.

The staff issued one follow-up RAI 558-4227, Question 06.05.01-11. The applicant responded on April 22, 2010 (ML101170172), to Question 06.05.01-11 with a revision to DCD Subsection

9.4.8 that included references to RG 1.29 and Appendix A to 10 CFR Part 50. Because the application meets regulatory expectations, the staff found the approach acceptable. The staff verified that Subsection 9.4.8 of DCD Revision 3 lists both RG 1.29 and Appendix A to 10 CFR Part 50 as references. The staff notes also that Revision 3 of the DCD significantly changed the format of Tier 1. As a result of this revision, Tier 1 Table 2.7.5.3-1 “Containment Ventilation System Inspections, Tests, Analyses, and Acceptance Criteria” now contains Item 4, which will ensure that the nonsafety-related portions of the as-built containment ventilation system will be analyzed and inspected against Seismic Category II requirements. Based on these changes, the staff **closed-- RAI 73-943, Question 06.05.01-1, Part 6 and RAI 558-4227, Question 06.05.01-11.**

In RAI 73-943, Question 06.05.01-1, Part 11, the staff noted that the four subsystems that comprise the containment ventilation system either contain Seismic Category I components or have components (e.g. AO valves, ducting etc.) in areas where safety-related Seismic Category I components are located. The staff found that none of the preoperational tests required verification as a Prerequisite that Seismic II/I construction is complete and that DC walkdown is complete before executing the preoperational test. The staff requested that the applicant add this requirement as a test “Prerequisite.”

In addition, the staff also noted that SRP 9.4.3 Section III.2.A indicates that the P&IDs should clearly indicate the physical divisions between essential and nonessential portions and indicate design classification changes. The flow diagrams shown in DCD Figure 9.4.6-1 did not show the boundaries between Seismic Category I safety-related components and nonessential components. The staff requested that the applicant provide additional information and clarify whether the seismic classification boundaries for the containment ventilation system safety related containment isolation valves should be shown in the Figure. The applicant responded on October 24, 2008 (ML083030089), and the staff issued follow-up RAI 558-4227, Question 06.05.01-17. The applicant responded on May 27, 2010 (ML101530606), with a revision of the DCD’s Tier 1 Tables and Tier 2 subsections. The staff notes that Revision 3 of the DCD significantly changed the format of Tier 1. As a result of this revision, Tier 1 Table 2.7.5.3-1 “Containment Ventilation System Inspections, Tests, Analyses, and Acceptance Criteria” now contains Item 4, which will ensure that the non-safety related portions of the as-built containment ventilation system will be analyzed and inspected against seismic Category II requirements. Similarly, Item 11 of Tier 1 Table 2.7.5.4-3 “Auxiliary Building Ventilation System Inspections, Tests, Analyses, and Acceptance Criteria”, ensures that the non-safety related portions of the as-built ABVS will be analyzed and inspected against Seismic Category II requirements. The staff also verified that DCD Revision 3 contained revised Tier 2 subsections consistent with the response to RAI 558-4227, Question 06.05.01-17. These changes meet regulatory expectations and resolve the staff’s documented concern for the CVVS. Based on these changes, the staff **closed RAI 73-943, Question 06.05.01-1, Part 11 and RAI 558-4227, Question 06.05.01-17.**

In RAI 73-943, Question 06.05.01-1, Part 12, the staff noted that the rotating piece parts of the fans of the containment ventilation system potentially all represent internally generated missile hazards to nearby safety-related components. Tier 2 DCD Section 9.4.6 fails to address this threat to safety-related components. The staff requested that the applicant amend Section 9.4.6 to discuss how this threat to plant safety is negated through the system design attributes. The applicant agreed to amend DCD Subsections 9.4.6.3.1; 9.4.6.3.3 and 9.4.6.3.4 for the fan housings and the containment low volume purge system and the containment high-volume purge system within the Containment to include a description of the containment ventilation system fan housings that are resistant to penetration of internally generated missiles. The staff confirmed that Revision 2 of the DCD contained the changes to Subsections 9.4.6.3.1, 9.4.6.3.3 and 9.4.6.3.4. The application now meets regulatory expectations and the staff found the applicant's responses to both RAI questions acceptable. The staff **closed RAI 73-943, Question 06.05.01-1, Part 12.**

Based on the staff's review of Revision 3 of the DCD, the foregoing RAI exchange and DCD enhancements, the staff concluded that the containment ventilation system as described in the US-APWR DCD satisfies the requirements of GDC 2.

9.4.6.4.2 GDC 5, "Sharing of Structures, Systems, and Components"

The staff reviewed the containment ventilation system to ensure that the relevant requirements of GDC 5 are met. Since this design application is for a single-unit plant, GDC 5 does not apply to this system.

9.4.6.4.3 GDC 41, "Containment Atmosphere Cleanup"

The staff reviewed the containment ventilation system to ensure that the relevant requirements of GDC 41 were satisfied as they relate to providing systems to control the release of fission products to the environment following a postulated accident (i.e. fuel handling accident within containment). The staff recognizes that the containment ventilation systems are not credited in the accident analysis for atmospheric cleanup but notes that systems may be functioning when an accident occurs. The staff determined to the extent applicable that the information contained in the DCD with respect to GDC 41 requirements was adequate.

9.4.6.4.4 GDC 42, "Inspection of Containment Atmosphere Cleanup"

The staff reviewed the containment ventilation system to ensure that, to the extent applicable, the relevant requirements of GDC 42 were satisfied as they relate to designing containment atmosphere cleanup systems to permit inspection. The staff confirmed that DCD Sections 9.4.6.4, 9.4.6.4.4.1 and 9.4.6.4.4.2 contain the good industry and maintenance practices consistent with GDC 42 and 43.

9.4.6.4.5 GDC 43, "Testing of Containment Atmosphere Cleanup Systems"

The staff reviewed the containment ventilation system to ensure that, to the extent applicable, the relevant requirements of GDC 43 were satisfied as they relate to designing containment atmosphere cleanup systems to permit pressure and functional testing. In RAI 73-943, Question 06.05.01-1, Part 16 the staff requested that the applicant amend DCD Section 9.4.6 and the relevant Preoperational Tests (i.e. 14.2.12.1.65, 14.2.12.1.66, 14.2.12.1.67, 14.2.12.1.68, 14.2.12.1.69 and 14.2.12.1.79) to include a test prerequisite to reflect the RG 1.52 "Design, Inspection, And Testing Criteria For Air Filtration and Adsorption Units Of Post-Accident Engineered-Safety-Feature Atmosphere Cleanup Systems In Light-Water-Cooled Nuclear Power Plants" provisions for filter replacement. The applicant responded October 24, 2008 (ML083030089), by noting that RG 1.140 contains this same post-construction and pre-operational requirement and that RG 1.140 applied to the filtration trains of the containment purge system.

Accordingly, the applicant provided an amendment to DCD Preoperational Tests 14.2.12.1.67, 14.2.12.1.68 and 14.2.12.1.79 with prerequisites that resolved the staff's concerns. The staff verified that Revision 3 of the DCD revised Preoperational Tests 14.2.12.1.67, 14.2.12.1.68 and

14.2.12.1.79 were in agreement with the applicant's RAI response. Based on this, the staff found the applicant's response acceptable and **closed RAI 73-943, Question 06.05.01-1, Part 16.**

As such, the relevant requirements of GDC 43 were satisfied as they relate to designing containment atmosphere cleanup systems to permit pressure and functional testing.

9.4.6.4.6 GDC 60, "Control of Release of Radioactive Material to the Environment"

The staff reviewed the containment ventilation system to ensure that the relevant requirements of GDC 60 are met. In particular, the staff reviewed the containment ventilation system to ensure that the system is capable of suitably controlling release of gaseous radioactive effluents to the environment. The standards invoked during this review were the guidelines of RGs 1.52 and 1.140 as related to design, inspection, testing, and maintenance criteria for post – accident and normal atmosphere cleanup systems, ventilation exhaust systems, air filtration, and absorption units.

ASME AG-1-1997 is the most recent version of ASME AG-1 endorsed by the staff.

In contrast, DCD Section 9.4.8 cites ASME AG-1-2003 as part of its licensing bases in Reference 9.4.8-2. The staff requested additional information about DCD Subsections 9.4.6.4.4.1 "Containment Low Volume Purge System" and 9.4.6.4.4.2 "Containment High Volume Purge System" and the use of ASME AG-1-1997. The staff requested in RAI 442-3378, Question 9.4.1-10 that the applicant provide justification for use of the newer code rather than the NRC-endorsed version of the code.

The applicant responded on September 18, 2009 (ML092650173), that the differences between the ASME Code AG-1-1997 edition referenced in the cited NRC guidance and the ASME Code AG-1-2003 referenced in the US-APWR DCD have been reviewed in order to justify the use of the later Code edition for ventilation system design and testing for the US-APWR. This review was based on the Summary of Changes provided in the AG-1-2003 Code since the 1997 edition. The applicant provided the results of the review in a table summarizing the comparison.

The changes to the Code were determined to be corrections and clarifications that do not affect the technical or administrative requirements of the Code. Therefore, the applicant concluded that use of the 2003 edition of the Code, rather than the 1997 edition referenced in the NRC guidance documents, is justified.

The staff conducted an independent side-by-side comparison of the two AG-1 Codes to confirm that the use of ASME AG-1-2003 edition is an acceptable alternative to ASME AG-1-1997 for TSC HVAC design and testing. From this comparison, the staff generated an RAI that documented three specific areas that required additional technical justification.

The staff requested in RAI 484-3850, Question 09.04.01-15, that the applicant provide a comprehensive technical justification (as applicable) for the use of AG-1-2003 and AG-1a-2000, in lieu of AG-1-1997, in the design of the US-APWR for the DCD. In addition, the staff requested that the applicant amend (as necessary) the relevant DCD subsections and tables to bring closure to the issues identified in RAI 484-3850, Question 09.04.01-15. The applicant responded on December 9, 2009 (ML093480146), with a thorough technical justification for the three specific areas of contention as documented by the staff in RAI 484-3850, Question 09.04.01-15. Based on this review, the staff concluded that, for the subject issue, the applicant has satisfied SRP guidance. Based on this finding the staff **closed RAI 484-3850, Question 09.04.01-15.**

In accordance with the review procedures of SRP 6.5.1, the staff asked the applicant to provide additional information about the sizing of the exhaust filtration units of the containment low-volume purge system and the containment high volume purge system. This was captured in RAI 73-943, Question 06.05.01-1, Part 10. The staff invoked the guidance of SRP 6.5.1 Sections 3.I.ii, and 3.I.iii with respect to the use of radioiodine decontamination factors in determining whether the guidance of RG 1.140 or RG 1.52 was followed in the design of the exhaust filtration units. The applicant responded on October 24, 2008 (ML083030089), with more detailed technical information. The staff found that the applicant's sizing of the exhaust filtration unit of the Containment High Volume Purge System is per the guidance of RG 1.140 and is therefore acceptable. The free volume of the Containment equals 2.8×10^6 ft^3 (Reference DCD Table 3.8.1-1). The containment low volume purge system fan can move 4.8×10^6 ft^3 of air over a 40 hour duration. [(2000 ft^3/min) (60min/hr) (40hr) = 4.8×10^6 ft^3]. Therefore, 1.7 air changes of the containment volume will take place over 40 hours. Based on this the staff found the applicant's sizing of the exhaust filtration unit of the containment low volume purge system acceptable. Based on the above conclusions, the staff **closed RAI 73-943; Question 06.05.01-1, Part 10.**

The staff concluded that for the containment ventilation system, the requirements of GDC 60 are satisfied.

9.4.6.4.7 GDC 61, "Fuel Storage and Handling and Radioactivity Control"

The staff reviewed the containment ventilation system to ensure that the relevant requirements of GDC 61 were satisfied as they relate to the design of systems for radioactivity control under normal and postulated accident conditions. The staff asked the applicant in RAI 73-943, Question 06.05.01-1, Part 3 how the exhaust filtration units of the containment low-volume purge system and the containment high-volume purge system satisfy Criterion 61 of 10 CFR 50 Appendix A. The staff could find no specific discussion of Criterion 61 within DCD Section 9.4.6. In particular, the staff inquired about the first three system design attributes of GDC 61. Criterion 61 reads:

> "*These systems shall be designed <u>(1) with a capability to permit appropriate periodic inspection and testing of components important to safety, (2) with suitable shielding for radiation protection, (3) with appropriate containment, confinement, and filtering systems</u>, (4)*"

The applicant responded October 24, 2008 (ML083030089), that GDC 61 does not apply to the containment purge system as this system does not serve any safety function and is not safety-related.

In RAI 558-4227, Question 06.05.01-16 the staff noted that the staff did not agree with the applicant's statement "*GDC 61 does not apply to the Containment purge system as this system does not serve any safety function and is not safety-related.*" The staff noted that generically and for the case in point the applicant is in error to imply that the criteria of 10 CFR 50 Appendix A only apply to safety-related systems with specific safety functions. The containment purge system of the US-APWR will have the capability to contain radioactivity during normal plant conditions (i.e. non Chapter 15 postulated accident conditions). Therefore, Criterion 61 does apply to the containment purge system. The applicant responded on May 27, 2010

(ML101530606), by providing an amended response to RAI 73-943, Question 06.05.01-1, Part 3 and revised DCD subsections 9.4.6.2.4.1 and 9.4.6.2.4.2 for the containment low-volume and high volume purge systems to include the words "…meets the GDC 60 and 61 requirements based on compliance with RG 1.140 and control of radioactive material release to environment." The staff found the applicant's response acceptable since the need for GDC 61 and RG 1.140 compliance is now assured by being part of the DCD description for the containment ventilation system. The staff confirmed that Revision 3 of the DCD contained these changes. Based on this, the staff **closed to RAI 73-943, Question 06.05.01-1, Part 3 and RAI 558-4227, Question 06.05.01-16.**

The staff concluded that the system meets the requirements of GDC 61.

9.4.6.4.8 GDC 64, "Monitoring Radioactivity Releases"

The staff reviewed the containment ventilation system to ensure that the relevant requirements of GDC 64 were satisfied as they relate to monitoring releases of radioactivity from normal operations, including AOOs, and from postulated accidents.

In RAI 73-943, Question 06.05.01-1, Part1, the staff requested additional information on how the containment area radiation monitors interface with the operation of the containment ventilation system (i.e. system interlock) and requested that a description of this interface and interlock be included in DCD Section 9.4.6. In particular, the staff contended that since the words contained in Section 14.2.12.1.69 "Containment Fan Cooler System Preoperational Test" reads "*The containment fan cooler system operates as described in Subsection 9.4.6.*" that the absence of this detail could lead to the interface and interlock not being tested during a plant's preoperational phase.

The applicant responded October 24, 2008 (ML083030089), that containment area radiation monitors (RMS-RE-91, RMS-RE-92, RMS-RE-93, and RMSRE-94 are part of the Area Radiation Monitoring System (ARMS). Chapter 12 of the DCD provides the details of these radiation monitors and discusses the interface and the interlock with the containment ventilation system. The applicant provided detailed information in the response, which that clarified the role of the system. The applicant in its response proposed changes to Section 9.4.6 of the DCD that would fully resolve the staff's concerns when implemented into the DCD. The staff found during its review of Revision 2 of the DCD that the applicant had failed to amend the DCD with three of the changes proposed in its response. Based on this, the staff issued RAI 558-4227, Question 06.05.01-12, which documented the applicant's failure. In its response dated April 22, 2010 (ML101170172), the applicant provided additional detail regarding system operation. The applicant provided an amended response to RAI 73-943, Question 06.05.01-1, Part 1. The amended RAI response revised DCD Subsection 9.4.6.3.4 to state that upon receipt of a containment low volume purge system low airflow alarm following closure of the containment isolation valves the containment low volume purge AHUs and associated exhaust fans will be manually shut down. The staff verified that Revision 3 of the DCD contained this change. The staff found the applicant's response acceptable since it removed any ambiguity from the DCD with respect to the interface between the CIS and the operation of the containment low volume purge system. Based on this, the staff **closed RAI 73-943, Question 06.05.01-1, Part 1 and RAI 558-4227, Question 06.05.01-12.**

In RAI 73-943, Question 06.05.01-1, Part 4 the staff noted that Tier 2 DCD Section 9.4.6 contains no reference to Criterion 64 of 10 CFR 50 Appendix A. The staff noted that it contains inadequate discussion about the monitoring of the effluents from the filtration units of the containment low volume purge system and the containment high volume purge system for radiation during normal operations, including AOOs and from postulated accidents. The staff requested that the applicant amend Section 9.4.6 to include discussion of GDC 64 and the system interface between the radiation monitoring system and the containment ventilation system. After a few RAI iterations, the applicant responded on May 15, 2009 (ML091390652), with a comprehensive response that provided the alarm locations, instrument locations, sampling configurations and function descriptions of radiation monitors RMS-RE-21A, -21B, -22, -23, -40, -41, -80A and -80B. The applicant proposed changes to DCD Figure 9.4.6-1, Section 11.5.2.2.2, Section 11.5.2.2.1 and Table 11.5-1 that would resolve the staff issues captured in RAI 300-2288, Question 06.05.01-3. The staff's review of Revision 2 and Revision 3 of the DCD confirmed that the applicant had revised Figure 9.4.5-1, Figure 9.4.6-1, Section 11.5.2.2.2, Section 11.5.2.2.1 and Table 11.5-1. Based on the revised information, the staff finds that the applicant provided enough information to confirm compliance with GDC 64 with the exception of the one issue. In RAI 615-4816, Question 06.05.01-19, the staff asked for further explanation from the applicant as to why the containment purge isolation function associated with radiation monitors RMS-RE-40 and 41 is not safety related. The applicant responded on September 29, 2010 (ML102770392), that the radiation monitors RMS-RE-40 and 41 are part of the process and effluent radiological monitoring and sampling system. This system is discussed in DCD Section 11.5.2.1 and these two monitors are specifically described in subsection 11.5.2.2 and are categorized as nonsafety-related. An excerpt from subsection 11.5.2.2 reads "*Detection of radiation above a predetermined setpoint activates an alarm in the MCR for operator actions and will automatically close the containment isolation valves on the containment purge ventilation system*." The applicant's response continued that these monitors provide a signal for the actuation of a system used to reduce gaseous effluent release with the RCS leakage into the containment. These monitors are required for plant operation and do not perform a safety function. As stated in DCD subsection 5.2.5.4, these monitors show a background level that is indicative of the normal level of unidentified leakage inside the containment. Variations in airborne radioactivity above the normal level signify an increase in unidentified leakage rates and signal plant operators to take corrective action. Therefore, the monitors are not credited with mitigating the consequences of design basis events by closing the containment isolation valves of the containment purge system. The safety-related monitors (RMS-RE-91A & B, 92A & B, 93A & B, and 94A & B) are credited with mitigating the consequences of a LOCA and abnormal high radiation inside the containment by closure of the containment isolation valves as stated in DCD subsection 12.3.4.1.1.

Based on the explanation above, the staff concurred with the applicant in that RMS-RE-40 and 41 need not be designated as safety-related since the monitors are not credited with mitigating the consequences of DBE. For further clarification, the applicant revised DCD subsections 9.4.6.2.4.1 and 9.4.6.2.4.2.

The staff verified that Revision 3 of the DCD contains this clarification. In summary, based on the foregoing conclusions and the verified changes to the DCD, the staff **closed RAI 73-943, Question 06.05.01-1, Part 4 and RAI 300-2288, Question 06.05.01-3.**

The staff concluded that the system meets the requirements of GDC 64.

9.4.6.4.9 10 CFR 52.47(b)(1),"Inspections, Tests, Analyses, And Acceptance Criteria ITAAC"

With RAI 73-943, Question 06.05.01-1, Part 19, the staff made the following observation: The third paragraph of Tier 2 DCD Section 9.4.6.4 reads "*All HVAC system airflows are balanced in* *conformance with the design flow, path flow capacity, and proper air mixing throughout the containment."* However, Section 9.4.6.4 does not contain any flow balance data that will allow the COL applicants to demonstrate and satisfy the above requirements. The staff requested that the applicant add this information to DCD Section 9.4.6.4. After several RAIs were exchanged, the applicant revised the third paragraph in DCD Section 9.4.6.2.1 to provide additional flow rate parameters for the four steam generator compartments and the pressurizer compartment. The staff confirmed that Revision 2 of the DCD contains the concise changes to the third paragraph in DCD Section 9.4.6.2.1 as identified above. Given the nonsafety-related status of the containment ventilation system, SRP guidance does not require a detailed engineering review/audit of the applicant's engineering calculations.

Therefore, the staff did not perform a detailed review of the sizing of the system. Rather, the staff cites the applicant's response dated September 29, 2009 to RAI 449-3495, Question 06.05.01-8 (ML092750207) and the enhanced acceptance criteria of subsection 14.2.12.2.4.11, "Ventilation Capability Test" as a justification for a finding that the applicant has resolved the staff's documented concerns. Based on this the staff **closed RAI 73-943, Question 06.05.01-1, Part 19.**

In RAI 449-3495, Question 06.05.01-8, the staff noted that through testing and analyses, the three internal subsystems of the containment ventilation system (i.e. containment fan cooler system, CRDM cooling system and reactor cavity cooling system) need to be demonstrated capable of keeping the Containment average air temperature at or below 120 °F. This demonstration would need to consider normal power operations and during design basis ambient summertime conditions (e.g. temperature, solar heat gain, wind velocities, etc., see DCD Table 9.4-1). The historical meteorological data for the COL applicant's site would provide the bases for these worst case ambient conditions. The staff requested that the applicant describe how the startup testing described in Section 14.2 would accomplish this or would be augmented to demonstrate the requirement. The staff also noted that, given the fact that the low volume purge system will not be used to satisfy the heating and cooling needs of the Containment during normal power operations, the staff needed additional information to clarify the intent of the COL action statement contained in DCD subsection 9.4.6.2.4.1. The statement reads "*The COL Applicant is to determine the capacity of cooling and heating coils that are affected by site specific conditions.*" More specifically the staff asked, what criteria is the COL applicant to use in the sizing of two-low volume purge systems' AHUs heating coils and cooling coils? The staff requested that the applicant amend the DCD to clarify this criterion.

In its response dated September 29, 2009 (ML092750207), to RAI 449-3495, Question 06.05.01-8, the applicant revised and enhanced preoperational test DCD Section 14.2.12.2.4.11, "Ventilation Capability Test" to demonstrate that the containment ventilation systems are adequately sized to maintain the system's design bases.

The staff verified that Revision 2 of the DCD accurately incorporated the concise changes to DCD Subsections 14.2.12.2.4.11, 9.4.6.1.2.4 and 9.4.6.2.4.1 as identified in Parts I and II of the "Impact on DCD" section of the applicant's response to RAI 449-3495, Question 06.05.01-8. In particular the staff notes that the Subsection 9.4.6.2.4.1 has been amended to include a design basis that reads "The supply air to the containment is dehumidified and tempered to minimize the condensation on the containment ventilation system's cooling coils and supply air duct inside the containment." This amendment provides the COL applicants with the needed guidance as to the sizing of the AHUs heating and cooling coils.

However, the staff still had one residual concern regarding the acceptance criterion D.1 wording of 14.2.12.2.4.11, “Ventilation Capability Test.” Following two RAI exchanges RAI 558-4227, Question 06.05.01-18 and RAI 615-4816, Question 06.05.01-20 (ML101170172 and ML102770392) the applicant proposed to amend D.1 with the words:

> "Temperature conditions are maintained in the containment and ESF areas in accordance with Subsections 9.4.5, 9.4.6, and Table 9.4-1. It has been demonstrated through testing and analyses that the temperatures for these areas are being maintained within the design temperatures based on the design basis environmental conditions and design basis heat loads."

The staff found this resolution to RAI No. 615-4816, Question 06.05.01-20 acceptable since it provided an acceptance criterion that was concise and not open to interpretation. The staff verified that Revision 3 of the DCD contained the above change. The staff concluded that the applicant resolved all issues associated with the three related RAI questions and **closed RAI 449-3495, Question 06.05.01-8; RAI 558-4227, Question 06.05.01-18; and RAI 615-4816 Question 06.05.01-20.**

In RAI 73-943, Question 06.05.01-1, Part 9 the staff asked the applicant about instrumentation used for recording concrete temperatures described in DCD Section 9.4.6.5.3. After several RAIs, the applicant provided a comprehensive response on May 15, 2009 (ML091390652), by invoking the nine categories of I&C that fall within the scope of SRP Chapter 7 as identified in Section 1.1 of NUREG-0800 SRP Section 7.1, *Instrumentation and Controls – Introduction.* Based on review of these nine SRP categories, the applicant considered the RCCS instrumentation described in DCD Section 9.4.6.5.3 to be outside the scope of SRP Chapter 7. The staff reviewed the applicant’s response and found it to be acceptable. In concluding its response, the applicant provided concise changes to DCD Section 9.4.6.5.3 that provided clarification. The staff verified that DCD Revision 3, subsection 9.4.6.5.3 contained changes consistent with the RAI response. Based on this and the DCD enhancements to the acceptance criteria of subsection 14.2.12.2.4.11, “Ventilation Capability Test” provided by RAI 449-3495, Question 06.05.01-8 (above), the staff **closed RAI 73-943, Question 06.05.01-1, Part 9.**

In RAI 73-943, Question 06.05.01-1, Part 20, the staff requested that the applicant provide additional details for the Section 9.4.6 containment ventilation system design. Numerous RAIs were exchanged in order to obtain enough design information to conclude the system would function as described. However, much of the detailed system design had yet to be completed. Given the Nuclear Safety Review (NSR) status of the containment ventilation system and based on SRP guidance, the staff opted not to perform a detailed engineering review/audit of the applicant’s engineering calculations to approve the specific design values provided by the applicant. Therefore, the staff did not specifically review and approve the technical information and data (e.g., flowrates, heat loads, cooling loads, margins, etc.) contained in the applicant’s responses to RAI 73-943, Question 06.05.01-1, Part 20 and RAI 300-2288, Question 06.05.01-6. Rather, the staff cites the applicant’s preoperational testing and responses to RAI 449-3495, Question 06.05.01-8 and RAI 615-4816, Question 06.05.01-20 (ML102770392) as discussed above, as a demonstration the system will function as described in the FSAR. Based on this the staff **closed both RAI 73-943, Question No. 06.05.01-1, Part 20 and RAI 300-2288, Question 06.05.01-6.**

In RAI 73-943, Question 06.05.01-1, Part 18, the staff cited inconsistencies between the information required for completion of the “CRDM Cooling System Preoperational Test” of DCD Subsection 14.2.12.1.65 and what information was contained or missing in DCD Section 9.4.6.

The information in question had to do with the lack of design specifications and lack of vibration alarm details contained in the relevant subsections and tables of Section 9.4.6 for this subsystem of the containment ventilation system. In its response dated October 24, 2008 (ML083030089), the applicant proposed changes to the DCD to remove these inconsistencies. Revision 2 of the DCD did not contain the necessary information to resolve many of the staff's concerns. The staff issued a follow-up RAI 558-4227, Question 06.05.01-14 to document that the proposed changes to the DCD were not incorporated in Revision 2 of the DCD. The applicant response on April 22, 2010 (ML101170172), to RAI 558-4227, Question 06.05.01-14 included a markup of the impacted DCD Subsections 9.4.6.5.3 and 14.2.12.1.66. These changes will eliminate all remaining inconsistencies between the DCD Chapter 14 preoperational tests for the subsystems that comprise the containment ventilation system and their corresponding Chapter 9 subsections. From its review of Revision 3 of the DCD, the staff determined that Subsection 9.4.6.5.3 had been amended consistent with the response to RAI 558-4227, Question 06.05.01-14. In contrast, the requisite change to subsection 14.2.12.1.66 did not appear in Revision 3. The staff issued RAI 826-6014, Question 06.05.01-21 to resolve this issue. In its response dated October 6, 2011 (ML11284A034), the applicant agreed to include the amendment in Revision 4 of the DCD. The staff holds this issue open as **Confirmatory Item -- RAI 73-943, Question 06.05.01-1, Part 18 and RAI 558-4227, Question 06.05.01-14; and RAI 826-6014, Question 06.05.01-21, Confirmatory Item 06.05.01-21.**

In RAI 73-943, Question 06.05.01-1, Part 17 the staff noted that DCD Section 9.5.1.2.7 "Building Ventilation" provided a general statement regarding HVAC attributes. The staff requested that the applicant amend DCD Section 9.4.6 to include a similar statement regarding what generic HVAC system attributes are applicable to the operation of four subsystems of the containment ventilation system. The applicant responded October 24, 2008 (ML083030089), that the containment fan cooler system, CRDM cooling system and reactor cavity cooling system do not penetrate any fire barrier that constitutes a fire area boundary within the containment. Therefore, there are no fire dampers installed as a part of these systems inside the containment. The applicant went on to note that the ductwork for the containment purge system is in the RB and the AB and its ductwork will be penetrating fire barriers. Therefore, fire dampers will be installed in this system. The containment penetration and the containment isolation valves are constructed of stainless steel material and act as a fire barrier and are equivalent to any fire-rated damper. They will prevent the spread of a fire from one fire area to another fire area. The installation of the fire dampers to a specific barrier penetration depends on the duct route, which have not been determined at this time. However, fire dampers will be installed where a fire-rated barrier has been penetrated by ductwork.

This type of fire damper will be released by a fixed temperature fusible link.

In its RAI response dated October 24, 2008, the applicant agreed to revise the DCD to incorporate the above mentioned fire protection attributes for the containment purge system of DCD Subsection 9.4.6.

The staff confirmed that DCD Revision 2 subsections 9.4.6.2.4.1 "Containment Low Volume Purge System" and 9.4.6.2.4.2 "Containment High Volume Purge System" contain sufficient detail and is in agreement with the applicant's RAI response. Based on this confirmation, the staff found the applicant's response acceptable. However, the staff noted an omission from Tier 1 Table 2.7.5.3-1 "Containment Ventilation System ITAAC" related to fire dampers. The staff initiated RAI 558-4227, Question 06.05.01-15 where the staff noted that the system interface with the fire protection system is fundamental to plant operations in its response to instances of smoke or fire within the areas served by the containment purge system. 10 CFR 50.48, Fire Protection and associated NRC RG 1.189, Revision 1 address preventing smoke from migrating from one fire area to another so that safe shutdown capability is not adversely affected.

The staff noted that Tier 1 Table 2.7.5.1-3 “Main Control Room ITAAC,” HVAC System Table 2.7.5.2-3, “Engineered Safety Features Ventilation System ITAAC” and Table 2.7.5.4-3, “Auxiliary Building Ventilation System ITAAC” all appropriately provide ITAAC for the ductwork fire dampers of the respective system. The staff requested that the applicant add a similar line item to Tier 1 Table 2.7.5.3-1, “Containment Ventilation System ITAAC” for fire dampers of the containment purge system. The applicant responded on April 22, 2010 (ML101170172), with a proposed change that would add line Item 3 to Tier 1 ITAAC Table 2.7.5.3-1 and add relevant fire damper information to Tier 1 subsection 2.7.5.3.1.1. The staff found both of these changes acceptable since these changes are consistent with the SRP guidance on ITTAC and meet the requirements on ITAAC.

The staff notes that Revision 3 of the DCD significantly changed the format of Tier 1. As part of this format change, Revision 3 of the Tier 1 ITAAC eliminated Section 2.7.5.3.1.1, "Containment Purge System **-** Design Description" under "Key Design Features." The staff finds this approach acceptable if the ITAAC of Table 2.7.5.3-1 is sufficiently comprehensive and well defined. The staff verified that DCD Revision 3 Tier 1 Table 2.7.5.3-1 “Containment Ventilation System Inspections, Tests, Analyses, and Acceptance Criteria” contains line Item 4 pertaining to fire damper testing and analyses. Item 4 reads that dampers in the ductwork of the containment purge system that penetrates the fire barriers are type tested and analyzed to ensure that the dampers will operate to protect safe shutdown capability. The staff notes that the ITAAC as written fail to demonstrate that the “as-built” fire dampers will fully close under system design flow rates. The staff notes that “type testing” consists of factory sample population testing. The staff is concerned that too many things can go wrong in the entire population of dampers, after the dampers are factory assembled. In particular, during shipping, during construction site storage; during component work site job staging; and during the actual installation (i.e. wrong or poor quality installation) to rely on the current words in Revision 3 of the ITAAC which fails to verify/demonstrate that the “as-built” dampers will fully close when required to close and to preserve the plant’s safe shutdown capability. Based on this concern, the staff issued **RAI 826-6014, Question 06.05.01-22 (ML11284A034).** The staff this RAI series as an **Open Item – RAI 73-943 Question 06.05.01-1, Part 17; RAI 558-4227, Question 06.05.01-15 and RAI 826-6014, Question 06.05.01-22, Open Item 06.05.01-22.**

The requirements contained in 10 CFR 52.47(b)(1) are further addressed in SER Section 14.3.7, Plant Systems – Inspections, Tests, Analyses, and Acceptance Criteria.

9.4.6.4.10 Other Staff Issues from SRP Guidance

In RAI 73-943, Question 06.05.01-1, Part 13, the staff noted that SRP 9.4.3 Sections III.1, III.3 and III.4 make reference to use of a FMEA, as appropriate, to confirm that the essential safety-related portions of the system are capable of functioning in spite of the failure of any active component, in the event of an earthquake, during LOOP, or a concurrent single active failure. The staff requested that the applicant provide additional information as to why an FMEA is not included in the DCD for the containment ventilation system. In its response dated October 24, 2008 (ML083030089), the applicant agreed to modify Subsection 9.4.6 of DCD Revision 2 and again, more specifically, in its response dated April 22, 2010 (ML101170172), the applicant agreed to add Table 9.4.6-2 “Containment Ventilation System Failure Modes and

Effects Analysis" to the DCD. The staff confirmed that the changes contained in Table 9.4.6-2 of the RAI response satisfied the SRP review requirements of SRP 9.4.3 Sections III.1, III.3 and III.4.

Based on this, the staff found the applicant's response acceptable. The staff verified that DCD Revision 3 contains these changes. Based on this, the staff **closed RAI 73-943, Question 06.05.01-1, Part 13.**

9.4.6.5 Combined License Information Items

None identified (COL 9.4(4) deleted in DCD Revision 3)

9.4.6.6 Conclusions

As set forth above in Sections 9.4.6.3 and 9.4.6.4 of this SE, the US-APWR containment ventilation system has been reviewed along with the RAI responses and US-APWR supporting information to determine if this design adequately meets the guidance given in SRP Sections 6.5.1 and 9.4.3. With resolution and closeout of the open item and confirmatory item noted below, the staff finds that DCD section 9.4.6 "Containment Ventilation System" is acceptable and meets the applicable requirements.

As documented in Section 9.4.6.4 of this report the following RAI question with sequential RAI questions remain as the lone Confirmatory Item in this SER.

- RAI 73-943, Question 06.05.01-1, Part 18; RAI 558-4227 Question 06.05.01-14, RAI 826-6014, Question 06.05.01-21.

The staff has an outstanding RAI question against the following open item as documented in Section 9.4.6.4 of this SE.

- RAI 73-943 Question 06.05.01-1, Part 17; RAI 558-4227 Question 06.05.01-15; RAI 826-6014, Question 06.05.01-22.

As set forth above in Sections 9.4.6.3 and 9.4.6.4 of this SE, for the US-APWR containment ventilation system, the staff concludes that the application meets the relevant requirements of 10 CFR Part 50, Appendix A, GDC 2, 5, 41, 42, 43, 60, 61 and 64 [not 10CFR52.47(b)(1) ITAAC] and is acceptable.

9.5 Other Auxiliary Systems

9.5.1 Fire Protection Program

9.5.1.1 Introduction

The objective of the US-APWR Fire Protection Program (FPP) is to minimize the potential for fire and explosion to occur; to promptly detect, control and extinguish any fire that may occur; and to assure that any fire will not prevent the safe-shutdown capability or significantly increase the risk of radioactive releases to the environment. The US-APWR FPP comprises of plant design and layout, fire protection systems, and administrative controls and procedures designed to prevent, mitigate, and limit the consequences of fires. The US-APWR FPP uses the concept of defense-in-depth to achieve the required degree of reactor safety through administrative controls, active and passive fire protection system (FPS) features, and post-fire safe shutdown capability assurance in accordance with SRP Section 9.5.1 and RG 1.189.

The US-APWR FPS is an integrated, complex system of equipment and components that provide early fire detection and suppression to limit the spread of fires. In addition to its fire protection functions, the FPS also performs a nonsafety-related defense-in-depth function by serving as a backup source of makeup water through piping connections to the CCW system and containment spray (CS) system, and water injection to the reactor containment cavity for severe accident mitigation.

The FPS does not perform any safety-related function and is classified as a non safety related, non-seismic system. However, seismic design requirements are applied to portions of the system located in areas containing equipment required for safe shutdown following a safe-shutdown earthquake (SSE). In addition, the FPS containment isolation valves and associated piping are safety-related (Equipment Class 2) and Seismic Category I.

In addition to meeting the applicable regulatory requirements, the US-APWR FPP and FPS are implemented in accordance with applicable industry codes and standards, including National Fire Protection Association (NFPA) 804, "Standard for Fire Protection for Advanced Light Water Reactor Electric Generating Plants" (2006 edition).

9.5.1.2 Summary of Application

Section 9.5.1, Fire Protection Program, includes key US-APWR fire protection design features and commitments by Mitsubishi Heavy Industries, Ltd. (MHI) that are set forth in the US-APWR DCD, Revision 3.

The US-APWR FPS design bases and features include the following:

- Plant buildings use noncombustible structural materials, primarily reinforced concrete, gypsum, masonry block, structural steel, steel siding, and concrete/steel composite material. Fireproofing of structural steel is not normally required throughout the plant. However, the effects of heat on structural steel are considered in the plant design and localized structural steel fireproofing may be provided, as required, to maintain rated fire capability of any associated barriers.

- The plant is subdivided into distinct fire areas and fire zones. Fire areas are completely enclosed by 3-hour rated fire barriers with all penetrations and openings protected with 3-hour rated components. Fire zones are typically separated from each other by 1-hour rated barriers where practical and are capable of substantially confining the adverse impact of potential fires and minimizing the risk of the spread of fire and the resultant consequential damage from corrosive gases, fire suppression agents, smoke, and radioactive contaminants.

- The fire areas' three-hour rated fire barriers provide complete separation of the four redundant safety trains, including equipment, electrical cables, and instrumentation and controls, except in plant areas where complete separation is not practical [MCR and reactor containment building]. For any fire outside the MCR and reactor containment building, this arrangement allows for one success path of safe-shutdown SSCs to remain free of fire damage to preserve the post-fire safe-shutdown capability using two of the three remaining redundant safety trains.

- Buildings outside primary containment generally have two or more enclosed stairways for emergency access. Firefighting personnel access and escape routes or access routes to areas containing equipment necessary for safe shutdown of the plant are clearly marked and equipped with emergency lighting. Such stairwells are enclosed in towers with fire resistant construction and having a minimum of two hours fire rating. Openings in stairways are protected with qualified automatic or self-closing doors having a fire rating of 1.5-hours or more.

- The FPS includes fire detection systems, vapor and liquid detection systems, fixed automatic and manual suppression systems, manual hose streams, and portable fire-fighting equipment and are installed throughout the plant to rapidly detect, control, and extinguish any fire that may occur. The FPS is designed such that any system failure or inadvertent operation of fire suppression systems will not adversely impact the ability of the SSCs important to safety to perform their safety functions and to preclude damage to plant safety-related SSCs in the event of an earthquake. The US-APWR Fire Hazard Analysis (FHA) (see Appendix 9A) evaluates the adequacy and level of fire protection provided for systems and plant areas important to safety.

- Fire and smoke dampers are installed to limit the spread of fire and combustion products and ensure that smoke, hot gases or fire suppressants will not migrate into other fire areas to an extent that could adversely affect safe-shutdown capabilities.

- A RSC with independent controls that are physically and electrically separated from the MCR is provided in another fire area to ensure the plant can be safely shut down in the event of fire damage to the MCR controls or in the event requiring MCR evacuation.

Operational and other site-specific aspects of the FPP are addressed by the COL applicants and are identified as COL action items in the US-APWR DCD. The COL action items include the establishment of a FPP to address the following:

- Organization, training, and qualification of plant personnel, including onsite and offsite fire brigade members.

- Administration control of combustibles and ignition sources, fire-fighting procedures, FPS periodic testing and quality assurance, and FPP updates.

- Site-specific designs and fire protection aspects of the facilities, buildings, and equipment (e.g., cooling tower and fire protection water supply system) that are not parts of the US-APWR standard design.

- Equipment for plant personnel and fire brigades (e.g., portable communication devices, portable fire extinguishers and SCBA).

9.5.1.3 Regulatory Basis

The staff reviewed the US-APWR DCD Tier 1, Section 2.7.6.9, “Fire Protection System,” and Tier 2, Section 9.5.1, “Fire Protection Program,” in accordance with Section 9.5.1, “Fire Protection Program,” Rev. 5, of NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants” (hereafter referred to as the SRP). In addition to the above, Tier 1 and Tier 2 sections related to the FPP and safe shutdown capability were reviewed to assess the overall capability and acceptability of the applicant’s FPP. The US-APWR FPP is acceptable if it meets the following regulatory requirements and regulatory guidance:

- Title 10, Section 50.48(a), of the *Code of Federal Regulations* (10 CFR 50.48(a)) requires that the holders of a combined license issued under Part 52 have a fire protection plan that meets GDC 3, “Fire Protection,” in Appendix A, “General Design Criteria for Nuclear Power Plants,” to 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities”; that the plan describe specific features necessary to its implementation; and that the licensee retain the plan and all changes to it as records until the (NRC or the Commission) terminates the reactor license.

- Under 10 CFR 52.47(a)(9) the application must include an evaluation of the facility against the SRP revision in effect six months before the docket date of the application.

- GDC 3 requires the following:

    - SSCs important to safety be designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions.

    - Noncombustible and heat resistant materials be used wherever practical throughout the unit.

    - Fire detection and fighting systems of appropriate capacity and capability be provided and designed to minimize the adverse effects of fires on SSCs.

  - Firefighting systems be designed to assure that their rupture or inadvertent operation does not significantly impair the safety capability of these SSCs.

- GDC 19, “Control Room,” requires the plant design to include a control room that allows plant operators to maintain the plant in a safe condition under normal and accident conditions and to make equipment available at alternate locations outside the control room to achieve and maintain hot shutdown with the potential capability for subsequent cold shutdown of the reactor.

- GDC 23, “Protection System Failure Modes,” requires that the reactor protection system be designed to fail in a safe state if postulated adverse environments occur, including extreme heat and fire and water discharged from fire suppression systems.

- 10 CFR 52.47(b)(I) requires an application for DC to contain proposed ITAAC which are necessary and sufficient to provide reasonable assurance that, if performed and acceptance criteria are met, a plant that references the design is built and will operate in accordance with the DC.

- 10 CFR 52.48, “Standards for Review of Applications,” requires that the application for a certified design be reviewed for compliance with the standards set out in 10 CFR Part 20, 50 and its appendices, 51, 73, and 100.

- SRP Section 9.5.1, Revision 5, “Fire Protection Program,” contains guidance and acceptance criteria for an FPP that meets the regulatory requirements described above.

- RG 1.189, Revision 3, “Fire Protection for Nuclear Power Plants,” provides guidance and acceptance criteria for one acceptable approach for an FPP that meets the regulatory requirements described above.

In addition to the regulatory requirements and guidance provided above, SRP Section 9.5.1 provides enhanced fire protection criteria for new reactor designs as documented in SECY-90-016, “Evolutionary Light Water Reactor (LWR) Certification Issues and Their Relationship to Current Regulatory Requirements,” dated January 12, 1990; and SECY-93-087, “Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs,” dated April 2, 1993.

9.5.1.4 Technical Evaluation

The staff reviewed the US-APWR FPP described in the US-APWR DCD, Revision 3, in accordance with 10 CFR 52.48 for a DC. The FPP is primarily described in Tier 1, Section 2.7.6.9, “Fire Protection System,” and Tier 2, Section 9.5.1, “Fire Protection Program,” including Appendix 9A, “Fire Hazard Analysis.” In general, the FPP for the US-APWR complies with the provisions specified in NFPA 804 as they relate to the protection of post-fire safe-shutdown capability and the mitigation of a radiological release resulting from a fire. However, the NRC has not formally endorsed NFPA 804 and some of the guidance in the NFPA standard conflicts with regulatory requirements. When conflicts occur, the applicable regulatory requirements and guidance, including the guidance in RG 1.189, will govern. The staff also reviewed the following Tier 1 and Tier 2 sections of the US-APWR DCD which contain related aspects of the US-APWR FPP for consistency in implementing the FPP:

- Tier 1, Section 2.2, "Structural and System Engineering."
- Tier 1, Section 2.5.2, "Systems Required for Safe Shutdown."
- Tier 1, Section 2.6, "Electrical Systems."
- Tier 1, Section 2.7.5, "Heating, Ventilation, and Air Conditioning Systems."
- Tier 1, Section 2.7.6.10, "Communication Systems."
- Tier 2, Section 1.2.1.5.4.7, "Fire Protection Systems."
- Tier 2, Section 3.1.1.3, "Criterion 3 – Fire Protection."
- Tier 2, Section 7.4, "Systems Required for Safe Shutdown."
- Tier 2, Section 8.3, "Onsite Power System."
- Tier 2, Section 9.5.2, "Communication Systems."
- Tier 2, Section 9.5.3, "Lighting Systems."
- Tier 2, Section 14.2.12.1.90, "Fire Protection System Preoperational Test."
- Tier 2, Section 19.1.5.2, "Internal Fires Risk Evaluation."
- Tier 2, Section 19.2.2.4, "Fire Protection."

In reviewing the above DCD sections, the staff determined that the FPP was developed in accordance with SRP 9.5.1, Revision 5, and the applicant has adequately described a fire protection plan for the US-APWR design, including the active and passive fire protection features, ITAAC requirements, and operational aspects of the FPP. As such, the FPP as described in the US-APWR DCD meets 10 CFR 52.47(a)(9), and 10 CFR 52.47(b)(I) requirements.

The US-APWR is constructed using noncombustible materials. The plant areas containing redundant safety-related equipment and cables (except for the MCR and the reactor containment building) are separated by 3-hour rated fire walls, ceiling and floor with 3-hour rated fire doors, fire dampers and penetration seals. Fire barriers are rated in accordance with industry codes and standards based on ASTM E-119 temperature curves. The limited use of cable raceway fire barriers to separate redundant safety-related components located in the same fire area are qualified in accordance with the guidance of RG 1.189 and GL 86-10 supplement 1. In response to a request for additional information (RAI 87-1514), in a letter dated November 26, 2008 (ML083360035), MHI clarified that cable fire barrier is one type of fire barriers included in the ITAAC described in item 15 of Table 2.2-4, Tier 1, of the DCD, and thus inspection of the as-built cable fire barrier will be performed if this type of fire barrier is used in the US-APWR. Based on the above, the staff determined that the US-APWR fire barrier designs are in accordance with the guidance of RG 1.189, and therefore satisfies the GDC 3 requirement regarding the use of non-combustible and heat-resistant construction materials.

The US-APWR design criteria also include the prevention of smoke migration between fire areas. Per MHI response to RAI 30-540 (ML082520817) dated September 3, 2008, smoke and heat cannot migrate from one fire area to another fire area that contains a redundant safe-shutdown train and/or equipment. As supplemented by MHI response to RAI 87-1514 (ML083360035) dated November 26, 2008, combination fire/smoke dampers will be used in ventilation ductwork that penetrate fire barrier walls separating redundant safety trains to prevent smoke migration into those areas containing digital instrumentation and control circuits. The combination fire/smoke dampers will be tested to operate under full operating HVAC flow rates. Based on the above, the staff determined that MHI adequately addressed the issue of smoke migration which may potentially affect post-fire safe shutdown.

Inside the reactor containment, redundant trains of safe shutdown components are separated whenever possible by existing structural walls, or by distance between defined fire zones. Cables of a safety-related division which pass through a fire zone of an unrelated division may be protected by cable raceway fire barriers or by noncombustible radiant heat shields having a minimum fire rating of 30 minutes with appropriate fire detection and suppression capabilities. The quantity of combustible materials in the containment is minimized. Also, an oil leakage collection system with a flash arrestor on the vent is provided for the RCP motors. Based on the above, the staff determined that the designed fire protection features and equipment arrangement within the reactor containment provide confidence that the adverse effects of fires on SSCs is minimized as required by GDC 3, and at least two of the four trains of safe shutdown equipment will remain undamaged following a fire in any fire area/zone.

For a fire in the MCR that may damage redundant safe shutdown equipment or requiring an evacuation, an RSC with independent controls that are physically and electrically separated from the MCR is provided in another fire area to ensure the plant can be safely shut down. The controls either in the MCR or at the RSC are adequate to safely shut down the plant. No other local operator manual actions are credited or required for achieving and maintaining post-fire safe shutdown. Based on the above, the staff determined that the GDC 19 requirement as stated in Section 9.5.1.3 of this SE is met.

To limit the combustible loading and fire hazards in the plant fire areas, the plant is constructed using noncombustible materials to the extent practicable. The selection of construction materials and the control of combustible materials are in accordance with the guidance of RG 1.189 and Section 3.3 of NFPA 804. Where conflicts occur, the guidance in RG 1.189 shall govern. Metal cable trays are used throughout the plant. Rigid metal conduit or other metal raceways are used for selected cable runs. Flexible metallic tubing may be used in short lengths for equipment connections. The insulating and jacketing materials for electrical cables are selected to meet the requirements of IEEE Standard 1202 or IEEE 383. The storage and use of hydrogen are in accordance with the guidance of NFPA 55 (COL 9.5(2)). Ventilation systems are designed to maintain the hydrogen concentrations in the battery rooms below 2 percent by volume. The TB and the turbine lubrication oil system, located in the TB, are separated from areas containing safety-related equipment by 3-hour rated fire barriers. The COL applicant takes measures to ensure that outdoor oil-filled transformers are separated from plant buildings in accordance with the guidance of NFPA 804 (COL item 9.5(2)). The primary diesel fuel oil storage for each emergency power source GTG and its associated transfer pumps is located in the yard area and is below grade within a substantial concrete vault confinement. Each GTG day tank located within its GTG room is provided with a spill confinement enclosure capable of holding 110 percent of the day tank capacity. The use of flame-retardant cables, metal raceways, and spill containment systems prevents and minimizes the potential of fire propagation from one area of the plant to another, and therefore, minimize the adverse effects of fires on SSCs as required in GDC 3. As such, the staff determined that the applicable requirement of GDC 3 as stated in Section 9.5.1.3 of this SER is met.

A fire water supply system, designed in accordance with the guidance of RG 1.189 and applicable NFPA codes and standards, is provided by the COL applicant. Redundant and independent water supply sources is provided, and the fire protection water supply system is sized such that it contains sufficient water for two hours operation of the largest US-APWR sprinkler system plus a 500 gpm manual hose stream allowance to support fire suppression activities. Adequate number of fire pumps is provided to allow for one pump to be out of service and still maintain 100 percent flow requirement. The detailed design of the fire protection water supply system is addressed by the COL applicant via COL Information Item 9.5(2). Fire protection water is distributed by an underground yard main loop, designed in accordance with the guidance of NFPA 24. Sprinkler and standpipe systems are supplied by connections from the fire main. Where plant areas, other than the containment and outlying buildings, are protected by both sprinkler systems and standpipe systems, the connections from the fire main are arranged so that a single active failure or crack in a moderate energy (such as fire protection) line cannot impair both systems. Manual valves for sectionalized control of the fire main or for shutoff of the water supply to suppression systems are electrically supervised. Hydrants are provided on the yard main in accordance with the guidance of NFPA 24 to provide hose stream protection for every part of each building and two hose streams for every part of the interior of each building not covered by standpipe protection. In addition, outdoor fire water piping and water suppression systems located in unheated areas of the plant are protected from freezing. Based on the redundancy of the fire water system and the associated distribution loop, as described in the DCD, the staff determined that a fire water source with adequate capacity would be available to support fire-fighting efforts per the general design requirement of GDC 3.

Manual fire suppression capability is provided in all areas of the plant, including areas that have an automatic fire suppression system. Manual fire suppression capabilities include the yard main hydrants, interior building hose stations, and portable extinguishers. Portable fire extinguishers are provided throughout the plant and are readily accessible for use in high radiation areas but are not located within those areas unless the FHA indicates that a specific requirement exists. Where the fire area is protected by manual suppression methods, the fire brigade responds to control and extinguish the fire. The fire brigade also responds when an automatic fire suppression system operates to assure the fire is controlled and suppressed and that the fire systems operation is terminated and reset to the standby readiness state. The qualification, training, and fire-fighting apparatus requirements for fire brigade members is addressed by the COL applicant via COL Information Item 9.5(1) and COL Information Item 9.5(3).

Automatic fire suppression systems including sprinkler, water spray, water mist, and gaseous suppression systems are used where appropriate and as prescribe by the FHA. For each area where a total flooding gaseous fire suppression system is identified, an environmentally-friendly fire suppression clean agent is used (Novec® 1230 fluid in a 5.6 percent concentration). Halon and carbon dioxide fire suppression systems are not used.

Fire detection and alarm systems are provided where required by the FHA in accordance with NFPA 72, NFPA 804, and RG 1.189. Fire detectors respond to smoke, flame, heat, or the products of combustion. The selection and installation of fire detectors also considers the type of hazard, combustible loading, the type of combustion products, and detector response characteristics. In areas where automatic fire detection systems are not installed, the applicant has installed manual fire alarm pull stations and manual fire suppression equipment. The applicant has also provided adequate assurance that the fire hazards in these areas are kept to a minimum, so that a fire in these areas will not challenge the equipment or cables of the redundant trains, which are separated by a three hour rated fire barrier. The types of detectors and detection system used in each fire area are identified in the FHA. The fire detection system provides audible and visual alarms and system trouble annunciation in the MCR and the security central alarm station. The fire detection systems may also result in actuation of pre-action valves or release gaseous fire suppression agent, as appropriate. In the Power

Source Fuel Storage Vault, a vapor and liquid detection system is used in-lieu of a fire detection system to provide early detection and warning. The staff reviewed MHI's response dated April 13, 2010 to RAI 537-4298, Revision 2, and found the use of a vapor and liquid detection system is acceptable as it can detect fuel oil leakage prior to initiation of a potential fire. The DCD Table 9A-2 is revised to reflect the use of a vapor and liquid detection system in-lieu of an automatic heat detection system in these fire areas.

The fire detection and suppression systems as described above provides assurance that any fire will be promptly detected and suppressed to minimize the adverse effects of fires on SSCs. In addition, the US-APWR FPS is designed such that any system failure or inadvertent operation will not adversely impact the ability of the SSCs important to safety to perform their safety functions. The fire brigade fire-fighting readiness and capability are also addressed by COL applicant. Therefore, the staff determined that the US-APWR FPP meets the applicable GDC 3 requirements pertaining to fire detection and fighting systems as stated in the Section 9.5.1.3 of this SE.

The DCD indicated that emergency lighting from 8-hour self-contained battery pack units is provided in all areas of the plant where emergency and safe shutdown operations are performed and where safe ingress and egress of fire brigade is required during loss of normal lighting. Emergency personnel and fire brigade members are also supplied with portable lighting. This design criterion is in accordance with RG 1.189 and provides assurance that the loss of power during post-fire scenarios will not adversely impact the fire-fighting and safe-shutdown capability. As such, the staff finds the emergency lighting design for the US-APWR acceptable.

Fixed emergency communications independent of the normal plant communication system are installed at predetermined stations. In addition, a portable radio communications system is installed for use by the fire brigade and other operations personnel required to achieve safe plant shutdown. This system does not interfere with the communications capabilities of the plant security force. Fixed repeaters are installed to permit use of portable radio communication units through the plant and are protected from exposure fire damage and have sufficient redundant such that if one repeater unit is out of service due to a fire or any other reason that capability of the emergency communication system is not adversely affected. The design criteria as described above is in accordance with RG 1.189 and provides assurance that the loss of power during post-fire scenarios will not adversely impact the fire-fighting and safe-shutdown capability. Per MHI response to RAI 87-1514 (ML083360035), these site-specific communication systems will be addressed by the COL applicants via COL Information Item 9.5(1).

The FHA, Appendix 9A, is conducted for the following primary plant structures and associated fire area and/or fire zones:

- Containment Vessel (C/V)
- RB
- AB
- TB
- Access Control Building (AC/B)
- PS/Bs
- ESW Piping Tunnel

The FHA includes a description of the fire areas, fire zones, fire barriers, type and quantity of combustible materials, and fire protection features in the fire area/zone. The FHA also includes evaluations of the fire protection adequacy, fire protection system integrity, post-fire safe shutdown capability, and potential radioactive release to the environment for each fire area. These evaluations provide assurance that the US-APWR installed active and passive fire protection features are adequate to contain the spread of smoke, fire, and combustion products, and preclude the potential for radioactive release to the environment due to a fire. The post-fire safe shutdown capability analysis provides assurance that fire effects from a single fire, including the effects of fire-induced multiple simultaneous spurious equipment actuations, will not damage or cause mal-operation of redundant safe-shutdown equipment to the extent that could adversely affect the safe-shutdown capability. The COL applicant shall update and maintain the FHA as required to address site-specific features and to develop pre-fire plans for each fire area/fire zone to facilitate fire brigade training and response to fire events (COL Information Items 9.5(1) and 9.5(2)). In reviewing the FHA, the staff determined that the initial development and the commitment to subsequent update and maintenance of the FHA by the COL applicant for the life of the plant adequately satisfy the FPP requirement for the DC phase of the US-APWR.

While the design criteria for all aspects of the FPP are provided in the DCD, some aspects of the FPP design cannot be fully described until plant equipment has been purchased and the detailed plant layout, including circuit routing, has been completed. In addition, the DCD notes that certain deviations from the US-APWR standard design may be taken by the individual plant licensees. These deviations as described in the DCD are permitted by NRC regulations, but may require formal submittal to the NRC for review and approval. As a minimum, the final design and deviations should be addressed in the final FHA and safe shutdown analysis in accordance with COL 9.5(2). The final design and deviation submittals should be made prior to arrival of fuel on site in accordance with regulations and the plant licensing basis. .

The US-APWR fire probabilistic risk assessment (PRA) is a simplified bounding type analysis. Per the response to RAI 30-540 (ML082520817), MHI stated that “No credit is being taken for reduction of fire protection features as a result of the PRA.” All fire protection features are provided in accordance with NFPA 804 and RG 1.189, Revision 3, requirements.

9.5.1.5 Combined License Information

None identified.

9.5.1.6 Conclusions

Based on the review of the US-APWR FPP design criteria and the commitments for their implementation as described in the DCD, the staff concluded that the US-APWR FPP is acceptable and meet the applicable requirements of 10 CFR Part 50 and 10 CFR Part 52, “Licenses, Certifications, and Approvals for Nuclear Power Plants”, as well as other acceptance criteria identified in Section 9.5.1.3 of this report, and are consistent with Commission policy contained in SECY-90-016 and SECY-93-087. The staff bases this conclusion on the applicant’s meeting the guidelines of the applicable regulatory guides and related industry standards as described in the DCD and as discussed in this SE**.**

By meeting the guidelines, the applicant’s FPP provides reasonable assurance that safe shutdown can be achieved assuming that all equipment in any one fire area (excluding the reactor containment) will be rendered inoperable by fire and that reentry into the fire area for repairs and operator actions is not possible. The applicant’s design provides an independent alternative shutdown capability that is physically and electrically independent of the MCR. The applicant’s design provides fire protection for redundant safe-shutdown systems to the extent practicable that will ensure at least two out of four required safe-shutdown divisions will be free of fire damage. Additionally, the applicant’s design provides reasonable assurance that fire, smoke, hot gases, or fire suppressant will not migrate from one fire area into other fire areas to the extent that they could adversely affect safe-shutdown capabilities, including operator actions.

Based on the above, the NRC staff concluded that the FPP as described in the US-APWR DCD, Rev. 3, meets the requirements of 10 CFR 50.48, “Fire Protection”; GDC 3; and 10 CFR Part 52.

9.5.2 Communication Systems

9.5.2.1 Introduction

The communication systems provide for effective intra-plant and plant-to-offsite communications during normal, transient, fire, accidents, off-normal phenomena such as LOOP, and security-related events. The intent of the various plant communication systems is to provide independent, alternate, redundant communication paths to ensure the ability to communicate with station and offsite agencies during all operating conditions. The plant communication systems are used for conveying verbal information as well as facsimile transmissions and in some cases digital based communications over links primary intended for verbal message transmission. Chapter 7 of this report addresses staff evaluation of US-APWR I&C design associated with data communications.

The plant communication systems are nonsafety-related. That is, the nuclear reactor can be shut down and maintained in a safe shutdown condition without the communications systems. However, these systems are important to safety in that they facilitate faster, easier, and more efficient safety functions under abnormal conditions such as fire, accidents, equipment failure, and security, as well as normal operations.

The staff’s review of the US-APWR communications system includes that portion of the system used in intra-plant and plant-to-offsite communications during normal operation, transients, fire, accidents, off-normal phenomena, and security-related events. Examples of normal operation intra-plant communication are during inservice testing, inspection, and maintenance. An example of normal operation plant-to-offsite communication is between plant operators and offsite electric power grid transmission organization staff to be informed of the nuclear power plant offsite power status. Other examples of plant-to-offsite communication are between plant operators and the NRC Incident Response Center and local authorities when the plant is operating during natural phenomena such as a tornado, hurricane, flood, tsunami, lightning strike, and earthquake. The staff’s review of security communications is presented in Section 13.6.

9.5.2.2 Summary of Application

DCD Tier 1: The Tier 1 information associated with this section is found in Tier 1, Section 2.7.6.10 and Table 2.7.6.10-1.

DCD Tier 2: The applicant has provided a Tier 2 description in Section 9.5.2, summarized here in part as follows:

> The applicant identifies the following communication systems, which are described as physically independent and nonsafety-related, but important to safety because they are needed for plant operation and security:
>
> - The public address/page system (two way, PA/PL), which provides intra-plant communications during operation, testing, calibration, startup, and off-normal conditions; the system interfaces with the plant telephone system, fire alarm system, and radiation monitoring system.
> - The telephone system (onsite and offsite communications, PABX), which connects to the offsite commercial telephone system and can provide normal and emergency communications.
> - The sound powered telephone system (SPTS), which requires no external power and serves as a backup communication system, or can be used for specific plant operations such as testing or refueling.
> - The plant radio system, which provides normal and emergency communications independent of the PA/PL, PABX, and SPTS.
> - Offsite communication systems, including emergency communication systems; details are site-specific, and would be presented by the COL applicant.
> - Plant security communication systems, which are described in DCD Section 13.6.
>
> The following locations within the US-APWR facility contain communication system arrangements:
>
> - RB and containment structure
> - TB
> - PS/B
> - AB
> - Access Building
>
> The design basis and design features of the communications systems are presented, including the governing codes and standards, as well as applications of the various systems for communication among specific onsite and offsite locations.

9.5.2.2.1 Public Address System/ Page (2 way communications, PA/PL)

The plant page system with audio messenger consists of an electronic amplification system with microprocessor-based mixers/amplifiers, controls, software, siren/tone and audio message generators, a centralized test and distribution cabinet, interfaces to other systems, and associated remote handsets and loudspeakers. The public address system interfaces with the plant telephone system, the fire alarm system, and the radiation monitoring system. In the event of a fire or radiation alarm, dedicated audio messages and alarm tones are activated.

The page system's primary function is intra-plant communications during plant operations, testing, calibration, startup, and off-normal conditions.

The PA/PL includes an audio messenger interface feature generates audio messages (tones or digitally pre-recorded speech or a combination of both) and broadcasts them over the system speakers during normal or emergency conditions, including evacuation procedures, repeating at preset time periods until cancelled. The audio messenger interface is connected to the plant radiation monitoring system. Activation of the radiation alarm automatically activates alarm and status messages appropriate to the level/location of the radiation alarm. The audio messenger interface is connected to the plant's fire alarm system. Activation of the fire alarm automatically activates alarm and status messages appropriate to the level/location of the fire alarm.

9.5.2.2.2 Telephone system (onsite and offsite communications, PBX)

The plant PABX is a digital-based multi-node telephone system. The plant PABX is connected to the offsite commercial telephone system and allows for normal and emergency communications. These connections may include offsite commercial telephone systems and the utility's private network, and are described by the COL applicant. Emergency communication lines are connected directly to specific telephones located in critical areas of the plant (e.g., MCR and TSC). The PABX is interfaced to the plant radio system thereby allowing personnel with plant radios the ability to originate telephone communications if necessary.

The plant has standard and emergency telephones which are hardwired to the PABX via outlet points (telephone jacks) and support communications within the plant and offsite. Emergency telephones are color-coded, (e.g., red), to distinguish them from normal telephones. These telephones are dedicated and are used for: the ENS to the NRC, local/state emergency notification, health physics network, plant security, and offsite emergency operations facility (EOF).

The PABX is powered from the plant non safety-related load group and consists of independent chargers and batteries for each PABX node. Each node can be switched over to another node's power source in case of its own power failure or for maintenance. However, the switching mechanism is interlocked such that each node can only be connected to a single source.

9.5.2.2.3 Sound Powered Telephone System (SPTS)

The SPTS is a dedicated means of communication that does not require external power sources. The SPTS is intended for use as a backup communications system or for use during special, specific plant operations (e.g., testing and refueling). The SPTS uses both fixed and portable sound powered telephone units. It is independent of the PA/PL and PABX systems. The applicant states that the function of the SPTS is to provide a dedicated communication system between key plant locations including: MCR, TSC, reactor refueling areas (inside and outside of containment), turbine-generator operating deck, remote shutdown console room; GTG rooms, electrical and mechanical equipment areas, other high maintenance activity areas (e.g., equipment hatch), and security facilities.

9.5.2.2.4 Plant Radio System

The plant radio system provides normal and emergency communications capability independent of the PA/PL, PABX and SPTS. Passive and active repeaters are distributed throughout the plant to ensure complete coverage anywhere in the facility. Low power portable radios are used with the system to reduce radio frequency interference (RFI) with control and instrument circuits. The system is designed to permit radio to radio and radio to MCR communications from any location within the facility. Communication consoles are located at select plant locations including the MCR, TSC, and remote shutdown consoles. The radios are equipped with multiple channels typically assigned as follows: emergency (alternate security), fire brigade (alternate security), operations, maintenance (alternate operations), management, health physics. Additional channels are assigned by the plant operator as necessary for select plant locations. Each system will be verified to be in conformance with 47 CFR (FCC) 15 Class A for RFI emission compliance.

9.5.2.2.5 Offsite Communication Systems

While the plant offsite communication systems detailed arrangements are generally site-specific and are described by the COL applicant, the plant will be provided with multiple offsite communications links such as microwave, hardwired (copper), broadband (cable), fiber optic and direct satellite. While the communication systems of DCD Tier 2 Section 9.5.2 primarily discuss verbal communication, links are also capable of data communications over the same connections. Thus a firewall system is provided to protect the plant broadband systems. Links are included that provide access to the nationwide telephone system.

9.5.2.2.6 Emergency Communication Features

Effective emergency onsite and plant-to-offsite communications is provided by the onsite PABX and the offsite emergency response center PABX systems. The two telephone system arrangement assures effective on-site and off-site communications under normal and emergency conditions. These are independent telephone systems consisting of digital commercial grade PABX telephone systems. They each have independent UPS. They effectively operate as independent facility telephone systems. These systems allow for communications during normal as well as abnormal situations including design basis accidents, fire, and loss of normal ac power. The offsite communication system is located in the offsite emergency response center. Details of the offsite communication system are described by the COL applicant in COL Information Item 9.5(8).

The PA/PL, PABX, and plant radio systems are normally used for intra-plant normal and emergency communications with the SPTS providing additional capability and backup. Radiation and fire alarms have priority over page. When the page system receives alarm inputs from the fire or radiation panels, it automatically provides audible messages and tone annunciation in accordance with specified schedules.

The PABX is powered from the plant non safety-related electrical load group and consists of independent chargers and batteries for each PABX node.

Some parts of the facility communication systems, related functions and external interfaces are the responsibility of the licensee and are addressed by the COL applicant. These COL Information Items include the communications aspects of the licensee’s security and detection systems, the emergency response center (10 CFR 50.34(f)(2) and 10 CFR 50.47(b)(8)), the TSC, the emergency plan (10 CFR 50 Appendix E) and fire response plans (GDC 3).

ITAAC: The ITAAC associated with Tier 2, Section 9.5.2 are given in Tier 1, Section 2.7.6.10 and Table 2.7.6.10-1.

TS: There are no TS for this area of review.

9.5.2.3 Regulatory Basis

The relevant requirements of the Commission's regulations for this area of review, and the associated acceptance criteria, are given in Section 9.5.2 of NUREG-0800 and are summarized below. SRP Section 9.5.2 refers to 10 CFR 73.55(e) and (f); however, they have been replaced with 10 CFR 73.55(i) and (j) to reflect the revised regulation 10 CFR 73.55 and the latter are addressed in this report. Further details and review interfaces with other SRP sections also can be found in Section 9.5.2 of NUREG-0800.

1. Appendix E to 10 CFR Part 50, "Emergency Planning and Preparedness for Production and Utilization," particularly Part IV.E(9), as it relates to the provision of at least one onsite and one offsite communications system, each with a backup power source.

2. 10 CFR 50.34(f)(2)(xxv), "Emergency Response Facilities," (TMI Action Plan Item III A.1.2).

3. 10 CFR 50.47(b)(6) and (8), (Equipment, communications, and facilities to support emergency response).

4. 10 CFR 50.55a, "Codes and Standards."

5. GDC 1, "Quality Standards and Records," found in Appendix A to 10 CFR Part 50, as it relates to the quality standards for design and fabrication.

6. GDC 2, "Design Basis for Protection Against Natural Phenomena," as it relates to being designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunamis, and seiches without loss of capability to perform their safety function.

7. GDC 3, "Fire Protection," as it relates to being designed and located to minimize, consistent with the other safety requirements, the probability and effect of fires and explosions.

8. GDC 4, "Environmental and Missile Design Bases," as it relates to 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.

9. GDC 19, "Control Room," as it relates to being capable of shutting down the reactor to a hot and cold shutdown condition from outside the control room.

10. 10 CFR 73.45(e)(2)(iii), "Performance Capabilities for Fixed Site Physical Protection Systems - Communications Subsystems."

11. 10 CFR 73.45(g)(4)(i), "Provide Communications Networks."

12. 10 CFR 73.46(f), "Fixed Site Physical Protection Systems, Subsystems, Components, and Procedures - Communications Subsystems."

13. 10 CFR 73.55(e), "Requirements for Physical Protection of Licensed Activities in Nuclear Power Reactors Against Radiological Sabotage - Detection Aids."

14. 10 CFR 73.55(f), "Communications Subsystems."

15. 10 CFR 73.55(i), "Detection and Assessment Systems."

16. 10 CFR 73.55(j), "Communications requirements."

17. 10 CFR 52.47(b)(1), which concerns proposed inspections, tests, analyses, and acceptance criteria (ITAAC)

Acceptance criteria adequate to meet the above requirements include:

1. RG 1.26, as it relates to the quality group classification of components.

2. RG 1.29, as it relates to the seismic design of the system.

3. RG 1.180, as it relates to the electromagnetic environment in which instrumentation and control (I&C) and communication systems are expected to operate.

4. RG 1.189, as it relates to fire protection requirements for nuclear power plants.

5. NUREG-0654, as it relates to communication devices in respiratory protective devices.

6. NUREG-0696, as it relates to the criteria for Emergency Response Facilities (ERFs)

7. IE Bulletin 80-15, as it relates to the Emergency Notification System (ENS)

9.5.2.4 Technical Evaluation

The plant's communication systems are not safety-related in that they are not needed to mitigate the consequences of a design basis accident. These systems are needed to operate the facility and to provide security for the plant by enabling each guard, watchman, or armed response individual on duty to maintain continuous communication with security forces and with appropriate agencies. Security communications and power are discussed in DCD Tier 2 Section 13.6.

The failure of any communications system does not adversely affect safe-shutdown capability. It is not necessary for plant personnel in safety-related areas of the plant to communicate with the MCR in order to achieve safe shutdown of the plant. There are multiple independent voice communications systems for emergency facilities and equipment and support onsite. The failure of any or all of their components does not affect any safety-related equipment.

DCD Tier 2 Section 9.5.2 does not specifically take any credit or mention personal cell phones or satellite phones as additional potential backup communication methods. However, DCD Tier 2 Section 13.3 states that the TSC provides telephones and facsimile machines, including land-line, cellular, and satellite communication capabilities, which utilize multiple methods of telecommunication including private lines, public lines, and satellite communications. The COL applicant is responsible for the details of the site-specific communications arrangements and can include details that may specifically address cell phones, satellite phones, microwave, and facsimile machines, and so on.

DCD Tier 2 Section 13.3 became specific on details concerning telecommunication in the TSC by stating that, "Ample working areas for all personnel as described in section 9.5.2." However, DCD Tier 2 Section 9.5.2 does not address "ample working areas." The staff issued **RAI 859-6105**, requesting the applicant clarify this discrepancy. The applicant's response (MHI Ref: UAP-HF-11415, dated November 30, 2011) states that the phrase was meant to say "plant communications systems are described in Subsection 9.5.2" and states the correction would be made in the next DCD revision. The staff finds this response acceptable and RAI 859-6105 is closed. This is a **Confirmatory Item 9.5.2-01**.

DCD Tier 2 Section 9.5.2 mentions the interface of the PA/PL with the fire alarm and radiation alarm. The staff would assume that these fire alarm and radiation alarms actuate messages, either manually or automatically, that include the specific building evaluation alarms and the site evaluation alarm (some sites even have manual site-wide tornado alarms), but this is not clear. Nor is there a mention of the remote warning system (sirens) that is certainly a critical part of the offsite communication with the public. The staff issued **RAI 860-6106**, requesting the applicant clarify this issue. The applicant's response (MHI Ref: UAP-HF-11418, dated December 02, 2011) lists locations in the DCD that answer the question and states no change is required in the DCD. The staff finds this response acceptable and RAI 6106 is closed.

9.5.2.4.1 10 CFR Part 50, Appendix E Requirements

10 CFR Part 50, Appendix E, IV.E(9) requires that adequate provisions shall be made as described for emergency facilities and equipment, including at least one onsite and one offsite communications systems, each with a backup power source. DCD Tier 2 Revision 3 Section 9.5.2.2 states that the following systems provide onsite communications: the PA/PL, the PABX telephone systems, the SPTS, and the plant radio systems, and also states that the plant PABX is connected to the offsite commercial telephone system and is used for both normal and emergency communications. Details of the PABX connections to both offsite commercial and the utility's private network are described by the COL applicant and are provided by adequately addressing COL Information Items 9.5(4), 9.5(5), 9.5(6), and 9.5(8). Effective emergency onsite and offsite communication is provided by the onsite PABX and the offsite emergency response center PABX systems that allow for communication during both normal and emergency situations. The plant radio systems also provide offsite communications. The PABX is powered from the plant non safety-related electrical load group and consist of independent battery chargers and batteries for each PABX node. Each node can be switched over to another node's power source. DCD Tier 2 Revision 3 Section 9.5.2.1.1 states the plant communications systems are independent of each other, and that they either have a built-in DC battery power source for the portable radios or are powered from non safety-related UPS system for the base stations and consoles. The SPTS does not require external power sources. Based on the above, the staff finds that the design meets the requirements of 10 CFR Part 50, Appendix E, IV.E(9) because the applicant has identified at least one onsite and offsite

communications systems with backup power sources and provided specific COL Information Items to address the details.

9.5.2.4.2 10 CFR Part 50 Requirements

10 CFR 50.47(b)(6) and (8) requires adequate equipment, communications, and facilities to support emergency response. SRP Section 9.5.2 states that information regarding 10 CFR 50.47(b)(6) and (8) will be found acceptable if adequate emergency facilities, communications, and equipment to support the response are provided and maintained including capability for prompt communications among principal response organizations to emergency personal and to the public. DCD Tier 2 Revision 3 Section 9.5.2.2 specifically describes communications systems and equipment that support emergency response including the PA/PL, the onsite PABX, the offsite emergency response center PABX , SPTS, and especially the plant radio system consisting of the crisis management radio system and the fire brigade radio system. DCD Tier 2 Revision 3 Section 13.3, “Emergency Planning,” provides a general description of the application of these communications systems for support in the TSC, OSC, and EOF as part of the emergency plan and is evaluated in Section 13.3 of this SER. The DCD Section also states that emergency planning is designated as the responsibility of the COL applicant and provides COL information items to address site specific details and requirements. DCD Tier 2 Revision 3 Chapter 17 addresses the QAP for equipment maintenance and is evaluated in Chapter 17 of this report. Therefore, based on the above, the staff finds that the design meets the requirements of 10 CFR 50.47(b)(6) and (8) with regard to communications systems because the various communications systems as described are sufficiently in quality, independent, redundancy, and diversity to provide for effective intra-plant, prompt notification and offsite communications during normal and emergency situations.

10 CFR 50.34(f)(2)(xxv) [TMI Action Plan Item III A.1.2] requires an applicant, among other things, to provide an onsite TSC for the facility. SRP Section 9.5.2 states that information regarding TMI Action Plan Item III A.1.2 is acceptable if provisions are made for an onsite TSC and an onsite OSC. DCD Tier 2 Revision 3 Section 13.3 states that emergency planning is designated as the responsibility of the COL applicant and provides COL Information Items to address site specific details and requirements. DCD Tier 2 Revision 3 Section 13.3 does not mention a OSC, but DCD Tier 2, Revision 3, Table 1.9.2-9, “US-APWR Conformance with SRP Chapter 9,” states conformance to SRP 9.5.2 with certain exceptions that are considered the responsibility of the COL applicants including item number 2 that refers 10 CFR 50.34(f) and an OSC. DCD Tier 2 Revision 3 Section 9.5.2 provides system descriptions of the communications systems for support in the TSC, OSC, and EOF. These include the PA/PL, the onsite PABX, the offsite emergency response center PABX , SPTS, and especially the plant radio system consisting of the crisis management radio system and the fire brigade radio system. The plant communication systems are arranged in a redundant fashion to provide for a minimum of two verbal communication paths between all plant locations and as well as external communications. Based on the applicant’s design descriptions of the various voice communication systems, the staff finds that the design meets the requirements of 10 CFR 50.34(f)(2)(xxv) with regard to communications systems because adequate communication systems are available for use in TSC, OSC, and EOF.

10 CFR 50.55a requires an applicant to address codes and standards. In DCD Tier 2 Revision 3, the applicant stated the plant’s voice communication systems are not safety-related in that they are not needed to mitigate the consequence of a design basis accident. In DCD Tier 2 Revision 3 Section 9.5.2.1.3, the applicant provided the codes and standards that apply to the communication systems. These include codes and standards from the National Fire

Protection Association (NFPA), UL, TIA, IEEE, and CFR. In other subsections of DCD Tier 2 Section 9.2.2, the applicant stated the communication systems are designed consistent with EPRI NP-6559, EPRI NP-5652, and EPRI TR-106439. The equipment is designed to be isolated or shielded from the adverse effects of EMI and RFI per RG 1.180. In DCD Tier 2 Revision 3 Table 1.9.2-9, the applicant indicates conformance with acceptance criteria number 4 regarding the requirements of 10 CFR 50.55a. Based on the communications descriptions and the information above, the staff finds that classification is acceptable for a non safety-related system and that the design has adequately addressed the requirements of 10 CFR 50.55a with regard to communications systems because of the commitment to acceptable codes and standards for the detail design and testing.

9.5.2.4.3 10 CFR Part 50, Appendix A, GDC Requirements

The GDC establish minimum requirements for the principal design criteria, providing guidance to ensure that SSC provide reasonable assurance that the facility can be operated without undue risk to the health and safety of the public. SRP Section 9.5.2 identifies the following GDC as applicable to communication systems: GDC 1, 2, 3, 4, and 19. DCD Tier 2 Section 9.5.2.1 states that the communications conform to the guidance provided in GDC 1, 2, 3, 4, and 19.

GDC 1 requires, in part, the SSCs important to safety are designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. As noted above, the applicant listed the codes and standards that apply to the communication systems. In DCD Tier 2 Section 9.5.2.4, the applicant stated that the analysis, design, fabrication, erection, inspection, testing and verification of the plant communication systems is to be performed in accordance with these codes and standards specified in DCD Tier 2 Section 9.5.2.1.3. The systems use high-grade industrial components. For the selection of these components, the applicant has addressed the guidance of EPRI TR-106439 for commercial grade digital equipment for nuclear safety applications and EPRI 5652 for the utilization of commercial grade items. Therefore, the staff finds the application of quality standards used in the selection of these components and systems to be sufficient and, accordingly, the requirements of GDC 1 have been met because the design is to be based on and tested by effective codes and standards.

GDC 2 requirements are met if SSCs important to safety are designed to withstand the effects of natural phenomena without loss of capability to perform their functions that are important to safety. The plant communication systems are designed, installed, and tested to demonstrate the ability to withstand the effect of natural phenomena appropriate to the respective plant locations. The analysis, design, fabrication, erection, inspection, testing and verification of the plant communication systems is performed in accordance with the codes and standards specified in DCD Tier 2 Section 9.5.2.1.3. Environmental conditions including weather, moisture, noise levels and electromagnetic RFI that might interfere with effective communication for vital areas is considered in the design and selection of the plant communication systems and components. The PABX is powered from the plant non safety-related load group and consists of independent chargers and batteries for each PABX node. The batteries have the capability to operate the plant telephone system for approximately 8 hours following loss of the normal ac power. Redundant communication paths and diverse technologies are employed to minimize the possibility of complete loss of on-site and off-site communications. DCD Tier 2 Section 9.5.2 does not specifically take any credit or mention personal cell phones as another potential backup communication method. The cell phone towers are part of the commercial network may be subject disruption by natural phenomena. Therefore, the staff finds the design of the communication systems meet the requirements of GDC 2 because the communication systems are appropriately designed to withstand the effects of natural phenomena without the loss of their mission functionality.

GDC 3 requires, in part, the SCCs important to safety are designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions. Noncombustible and heat resistant materials shall be used wherever practical throughout the unit, particularly in locations such as the containment and control room. The applicant has indicated these communication systems include use of NFPA standards in the design, the use of various interfaces to the fire alarm system, using channel separation, and using some portable devices. Radio repeaters are installed in suitable fire resistant enclosures to protect them from exposure to fire, smoke, water, and dust in accordance with RG 1.189. The components for the SPTS are flame retardant, watertight, and installed at specific points in the plant to provide a reliable backup communication system. The circuits for the PA/PL from the main page equipment to each component junction box are ring-wired to preclude loss of the system function in the event of a single cable failure. The applicant has also identified COL Information Items applicable to a fire protection program inclusive of these communication systems. Therefore, the staff considers the requirements of GDC 3 are met because the designs, as described, adequately address reducing the probability and effect of fire and explosion.

GDC 4 requires that SSCs important to safety be 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. The staff evaluated the applicant's descriptions of the environments in which the communication system components are qualified to operate in. The communication systems receive power from non-class 1E UPS and can operate through LOOP and SBO events that could be caused by environmental conditions as a hurricane. The design bases help ensure that the ability to communicate with the station and offsite agencies during all operating conditions is preserved. DCD Tier 2 Revision 3 Section 9.5.2 identifies that the communication systems are qualified to operate in all plant environments. Depending on the specific installed plant location, the selected components are qualified to operate in the environments, as applicable, including, extremely noisy locations, humid and oily locations, hazardous areas, outdoors (where indicated,) indoor areas with thick concrete walls or other obstructions, with personal wearing protective equipment, and areas having constant vibration. Specifically, the applicant identified the communication systems are designed to be used with respiratory equipment consistent with the guidelines provided in EPRI NP-6559 and guidance delineated in RG 8.15. The applicant states the equipment is designed to be isolated or shielded from the adverse effects of electromagnetic interference (EMI) and RFI per RG 1.180. Therefore, the staff considers the requirements of GDC 3 are met because the design of these communication systems as described accommodate the effects of and are compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents.

GDC 19 requires, in part, that equipment at appropriate locations outside the control room shall be provided with a design capability for prompt hot shutdown of the reactor, including necessary I&C to maintain the unit in a safe condition during hot shutdown. The plant communication systems can facilitate shutdown of the reactor from outside of the MCR by providing communications between the remote shutdown console and other plant locations. If all systems requiring a power source were to fail, the operators can still utilize the SPTS to communicate between critical plant areas, including the remote shutdown consoles. The portable wireless communication system has an adequate number of channels to accommodate anticipated functions such as fire, operations, health physics, fuel reloading, emergency, and security. GDC 19 is not directly applicable to the communications systems. The reactor can be shut down safely without these non safety-related systems. Accordingly, the communications systems need not be credited in evaluating compliance with GDC 19. However, the staff finds the requirements of GDC 19 are effectively met from the communication perspective, because the various independent and diverse communications systems significantly increase the overall command and control the reactor operators have over the plant by providing the ability to communicate and direct activities with operations, maintenance, health physics, firefighters, security, and rescue teams in the plant.

9.5.2.4.4 10 CFR Part 73 Requirements

10 CFR 73.45(e)(2)(iii) requires that communications systems and procedures provide for notification of an attempted unauthorized or unconfirmed removal of strategic special nuclear material. DCD Tier 2 Revision 3 Section 9.5.2.2 identifies that the US-APWR has a completely independent plant security communication systems for security purposes. Other communications systems such as the PA/PL, PABX, and the plant radio system are available as alternate means if necessary. The application of the communications systems described in DCD Tier 2 Revision 3 Section 9.5.2 in support of conformance to 10 CFR 73.45(e)(2)(iii) is evaluated in Section 13.6 of this report under conformance to 10 CFR 73.55 and the security plan.

10 CFR 73.45(g)(4)(i) requires rapid and accurate transmission of security information among onsite forces for routine security operation, assessment of a contingency, and response to a contingency. SRP Section 9.5.2 states information regarding the requirements of 10 CFR 73.45(g)(4)(i) will be found acceptable if communications networks are provided to transmit rapid and accurate security information among onsite forces for routine security operation, assessment of a contingency, and response to a contingency. DCD Tier 2 Revision 3 Section 9.5.2.2 identifies that the US-APWR has a completely independent plant security communication systems for security purposes. The PA/PL, PABX, and plant radio system are physically independent systems and can serve as backup systems in the event of failure of the plant security communication system. The application of these security communications for security purposes is addressed in DCD Tier 2 Revision 3 Section 13.6 and evaluated in Section 13.6 of this report. The staff finds that communications systems have the capability to provide a backup support for transmission of the security information required by 10 CFR 73.45(g)(4)(i).

10 CFR 73.46(f) requires that the communications systems shall be capable of maintaining continuous communications between each guard, watchman, or armed response individual on duty with the manned alarm stations. SRP Section 9.5.2 states that information regarding the requirements of 10 CFR 73.46(f) will be found acceptable if (1) each guard, watchman, or armed response individual on duty shall be capable of maintaining continuous communications with an individual in each continuously manned alarm station required by 10 CFR 73.46(e)(5), who shall be capable of calling for assistance from other guards, watchmen, and armed response personnel and from law enforcement authorities; (2) each alarm station required by 10 CFR 73.46(e)(5) shall have both conventional telephone service and radio or microwave transmitted two-way voice communication, either directly or through an intermediary, for the capability of communications with the law enforcement authorities; and (3) non-portable communications equipment controlled by the licensee and required by 10 CFR 73.46(f) shall remain operable from independent power sources in the event of the loss of normal power. DCD Tier 2 Revision 3 Section 9.5.2 specifies that the communications systems enable each

guard and watchmen, or armed response individual on duty to maintain continuous communications with security forces, manned alarm stations, and with appropriate agencies as required by 10 CFR 73.55(e) and (f). Security communications are evaluated in Section 13.6 of this report. Further, the PA/PL, PABX, and plant radio system are physically independent systems powered either by a built-in DC battery power source (e.g. portable radios) or from non safety-related UPS systems capable of operating through a (LOOP or SBO). They serve as backup to one another in the event of system failure as well as having the capability needed to be a backup for the security communications system. These three independent voice communications systems are designed and installed to provide assurance that any single event does not cause a complete loss of intra-plant communication. This is accomplished by the use of diverse technology, separate routing of cables, available wireless communications (radio), and UPS backed power supplies. Accordingly, the staff finds that the communications systems design has the capability to provide effective backup support as needed to the security communication systems as an alternate means of meeting the communications required by 10 CFR 73.46(f).

9.5.2.4.5 10 CFR Part 73.55 Requirements

10 CFR 73.55(e) and 10 CFR 73.55(i) apply to physical protection of licensed activities in nuclear power reactors. The application of communications systems as supporting systems is described in DCD Tier 2 Revision 3 Section 13.6, and evaluated in Section 13.6 of this report.

10 CFR 73.55(j) requires: (1) the licensee shall establish and maintain continuous communication capability with onsite and offsite resources to ensure effective command and control during both normal and emergency situations; (2) individuals assigned to each alarm station shall be capable of calling for assistance; (3) all on-duty security force personnel shall be capable of maintaining continuous communication with an individual in each alarm station, and vehicle escorts shall maintain continuous communication with security personnel; (4) the following continuous communication capabilities must terminate in both alarm stations required by this section: radio or microwave transmitted two-way voice communication, either directly or through an intermediary, in addition to conventional telephone service between local law enforcement authorities and the site and a system for communications with the control room; (5) non-portable communications equipment must remain operable from independent power sources in the event of the loss of normal power; and (6) the licensee shall identify site areas where communication could be interrupted or cannot be maintained, and shall establish alternative communication measures or otherwise account for these areas in implementing procedures. DCD Tier 2 Revision 3 Section 9.5.2 identifies that the US-APWR has a completely independent communication system for security purposes that is capable of maintaining continuous communication capability with onsite and offsite resources to ensure effective command and control during both normal and emergency situations. The emergency communication system has color-coded telephones for offsite communications with the NRC, state officials, state and local emergency centers, local fire departments, and local police authorities. The PA/PL, PABX, and plant radio systems are physically independent systems and can serve as backup systems in the event of failure of the security communication system. The plant sound-powered telephone provides another diverse system that does not require external power. DCD Tier 2 Revision 3 Section 9.5.2 identifies the PA/PL, PABX, and plant radio systems as physically independent systems powered from diverse non safety-related power supplies. These three independent voice communications systems are designed and installed to provide assurance that any single event does not cause a complete loss of intra-plant communication. The application of these communications for security purposes is addressed in DCD Tier 2 Revision 3 and Section 13.6. DCD Tier 2 Section 13.6 is evaluated in

Section 13.6 of this report. The application of these communications in the emergency plan that directs the application, command, and control of communication with offsite agencies is addressed in DCD Tier 2 Revision 3 Section 13.3 involving the emergency plan. DCD Tier 2 Section 13.3 is evaluated in Section 13.3 of this report. Both of DCD Tier 2 Sections 13.6 and 13.3 include COL Information Items that direct the COL applicant to providing site specific details. Based on the above the staff finds that the requirements of 10 CFR 73.55(j) are adequately addressed with regard to the communications systems design, because redundant, independent, and diverse communication equipment of the design provides the capability to support continuous communication needs for both normal and emergency situations.

9.5.2.4.6 ITAAC Requirements

10 CFR 52.47(b)(1) requires that a 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, and the NRC's regulations. ITAAC specific to the US-APWR Communication systems is found in Tier 1 Section 2.7.6.10. The staff finds that these ITAAC and the content of DCD Tier 2 Section 9.5.2, as discussed in this section of the report, will provide an essentially complete bounding design with the site-specific elements provided by the COL applicant. The staff finds the ITAAC acceptable because the ITAAC will verify the as-built general functional arrangement of the communication systems as described in the design description of Section 2.7.6.10.1, will verify the means exists for communications between the MCR and TSC and from the MCR and TSC to EOF, principal State and local emergency operations centers, and radiological field assessment teams, and will verify the means exist for communications from the MCR and TSC to the NRC headquarters and regional office emergency operations centers (including establishment of the emergency response data system.)

9.5.2.4.7 NUREGs and IE Bulletin 80-15

NUREG-0696, in part, specifies the voice and data communication support required for the TSC, OSC, and the EOF, and the relationship of these to the MCR. NUREG-0654, Supplement 1, Section II.E, in part, specifies notification methods and procedures for offsite communications in support of emergency preparedness, and Section II.F, in part, specifies emergency communications for offsite communications in support of emergency preparedness. These requirements are addressed in DCD Tier 2 Section 13.3 concerning the emergency plan and include COL Information Items to direct the COL applicant to provide application details. DCD Tier 2 Section 13.3 is evaluated in Section 13.3 of this report. DCD Tier 2 Section 9.5.2 describes the multiple, redundant, and diverse communications and redundant power sources that are applied to achieve compliance with the physical communication equipment guidance of NUREG-0696 and NUREG-0654.

IE Bulletin 80-15 states, in part, that, " … all extensions of the ENS located at your facility(ies) would remain fully operable from the facility(ies) to the NRC Operations Center in the event of a loss of offsite power to your facility(ies)." The plant communication systems are powered from non safety-related UPS systems. For example, The PABX is powered from the plant non safety-related electrical load group and consists of independent chargers and batteries for each PABX node. The batteries have the capability to operate the plant telephone system for approximately 8 hours following loss of the normal ac power. The plant radio system is powered from non-Class 1E UPS system for the base station and consoles. Portable, hand-held radios have internal, exchangeable, rechargeable batteries, while non-portable radio communications equipment remains operable from independent power sources in the event of loss of normal power modes. Further, in COL Information Item 9.5(4), the COL applicant is to include consideration of the concerns raised in IE Bulletin 80-15. Therefore, the staff finds the communication systems design meets the guidance of IE Bulletin 80-15 because the ENS is expected to remain operable even in the event of the loss of the normal primary power source.

9.5.2.5 COL Information Items

The following COL Information Items associated with the US-APWR communication systems are listed in DCD Tier 2, Section 9.5.9 and Table 1.8-2:

Table 9.5.2-1
US-APWR Combined License Information Items

Item	Description	Section
9.5(4)	*The COL applicant addresses all communication system interfaces external to the plant (offsite locations). These include interfaces to utility private networks, commercial carriers and the federal telephone system. The configuration of these connections will include consideration of the concerns raised in IE Bulletin 80-15.*	9.5.2
9.5(5)	*The COL applicant addresses the emergency offsite communications, including the crisis management radio system.*	9.5.2
9.5(6)	*The COL applicant addresses connections to the Technical Support Center from where communications networks are provided to transmit information pursuant to the requirements delineated in 10 CFR Part 50, Appendix E, Part IV.E.9.*	9.5.2
9.5(7)	*The COL applicant addresses a continuously manned alarm station required by 10 CFR 73.46(e)(5) and the communications requirements delineated in 10 CFR 73.45(g)(4)(i) and (ii). The COL applicant addresses notification of an attempted unauthorized or unconfirmed removal of strategic special nuclear material in accordance with 10 CFR 73.45(e)(2)(iii).* (See note below.)	9.5.2
9.5(8)	*The COL applicant addresses offsite communications for the onsite operations support center.*	9.5.2
9.5(9)	*The COL Applicant addresses the emergency communication system requirements delineate in 10 CFR 73.55(f) such that a single act cannot remove onsite capability of calling for assistance and also as redundant system during onsite emergency crisis.* (See note below.)	9.5.2

Note: For the DC, the applicant determined that the requirements of 10 CFR 73.20, 73.45 and 73.46 are not applicable to the US-APWR in Section 9.5.2. Therefore, the next revision of DCD Section 9.5.10 will delete references to these three requirements, and COL Information Items COL 9.5(7) and COL 9.5(9) will also be modified or deleted. This will be tracked as a **confirmatory item.**

9.5.2.6 Conclusions

Assuming the verification of the confirmatory items in the Revision 4 of the DCD then the conclusion will be:

Based on its review summarized above and to the extent they addressed the use of the communications systems in intra-plant and plant-to-offsite communications in support of the plant in normal, emergencies, and security functions, the staff finds that the communications systems designs are acceptable and meet the applicable requirements of 10 CFR Part 50 and 10 CFR 73 specifically listed above, NUREG-0654, NUREG-0696, and guidance from RG 1.189, Position 4.1.7 and NRC Bulletin 80-15. The basis for the staff's conclusion includes the finding that: (1) The design provides for at least one acceptable onsite and one acceptable offsite communication system with backup power sources and provided specific COL Information Items to address the details; (2) The design provides communications systems with capability for prompt notification and continuing communication to the NRC; (3) The design provides communications systems with capability for prompt notification and continuing communication with site, local and state response organizations; (4) The design provides a variety of diverse communication systems involving both private links, commercial links, site public address, microwave, facsimile, and radio with the capability of adequately supporting both normal use and emergency situations; and (5) the non-safety communication systems do not prevent completion of safety functions.

9.5.2.7 References

References for Section 9.5.2 of this report follow:

9.5.2-1, "Voice Communication Systems Compatible with Respiratory Protection, EPRI NP-6559," November 1989.

9.5.2-2, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants," NUREG-0654/ FEMA-REP-1, Revision 1, November 1980.

9.5.2-3, RG 1.180, "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems," Revision 1, October 2003.

9.5.2-4, RG 1.189, "Fire Protection for Nuclear Power Plants," Revision 1, March 2007.

9.5.2-5, EPRI TR-106439, "Guideline on Evaluation and Acceptance of Commercial Grade Digital Equipment for Nuclear Safety Applications," October, 1996.

9.5.3 Plant Lighting System

9.5.3.1 Introduction

The staff's review of the US-APWR lighting system assesses the capability of the normal lighting system to provide adequate lighting during all plant operating conditions (i.e., normal operation and anticipated fire, transient, and accident conditions) and the capability of the emergency lighting system to provide adequate lighting during all plant operating conditions, including fire, transient and accident conditions. The effect of loss of all alternating current (ac) power (i.e., during a SBO) is specifically evaluated. The review includes the applicant's normal and emergency lighting system failure analysis.

9.5.3.1 Summary of Application

DCD Tier 1: The Tier 1 information associated with this section is found in Tier 1, Section 2.6.6 and Table 2.6.6-1.

DCD Tier 2: The applicant has provided a Tier 2 description in Section 9.5.3, summarized here in part as follows:

> The lighting systems include: normal lighting; normal lighting powered from the non-Class 1E 480 Vac system; emergency lighting; Class 1E emergency lighting powered from the Class 1E 480 Vac system and 125 Vdc system; normal/emergency lighting powered from the non-Class 1E 480 Vac system, backed up by the alternate ac power sources for SBO or loss of offsite power conditions; and emergency lighting powered by 8-hour self-contained battery pack units that are normally powered from the non-Class 1E 480 Vac system or the Class 1E 480 Vac system, as applicable.
>
> The applicant states that Class 1E emergency lighting is provided in areas where emergency operations are required to safely shutdown the reactor, and maintain the plant in a safe shutdown condition during design basis events. A description of the lighting systems, the design basis, and design features are presented. Section 13.6 of this report discusses the security lighting system.
>
> The lighting systems provide for adequate lighting during normal plant operation, transient, fire, accidents, and off-normal events. The lighting fixtures circuits in an area (other than self-contained battery pack emergency lighting units) are powered by circuits from separate load groups and the circuits are staggered as much as practical to ensure availability of the minimum required lighting in case of failure of a circuit or load group. The emergency lighting systems are required to remain "ON" during normal plant operation and emergency conditions. Emergency lighting is provided in areas required for safe shutdown of the plant, restoring the plant to normal operation, firefighting, and safe movement of people to the access and egress routes during plant emergencies and loss of normal power supply. Emergency lighting from the Class 1E system is also supplemented by 8-hour self-contained battery pack units. The normal/emergency (N/E) lighting system is powered from the normal power system during normal operation and from the non-Class 1E alternate ac power source during SBO or LOOP conditions. The lighting circuits are non-Class 1E. The emergency lighting circuits connected to the Class 1E power supplies are provided with Class 1E isolation devices. The design of the lighting system for areas containing rotating machinery includes provisions such as feeding the fixtures in the area from different phases of the power supply or use of electronic ballasts to eliminate the risk of stroboscopic effects caused by the lamp flicker.
>
> High intensity discharge (HID), fluorescent, and mercury vapor lamps or switches are not used in fuel handling areas or containment. Incandescent lighting or other lighting not containing restricted material is used in those areas. Fluorescent lamps are generally used for indoor, enclosed areas. High-pressure sodium vapor lamps are generally used for roadways and parking areas. Metal halide lamps are generally used for general plant indoor high bay or low bay lighting, outdoor lighting, and all classified locations. Incandescent lamps are used for emergency dc lighting.
>
> Lighting system bulbs are not seismically qualified. The lighting fixtures for normal lighting located in vicinity of Class 1E equipment are supported so that they do not adversely impact Class 1E equipment when subjected to the seismic loading of a SSE. Emergency lighting fixtures in Class 1E equipment areas are mounted on Seismic Category I structures. The MCR and RSC normal lighting provides 50 foot-candles on the consoles and safety panels and uses low glare lighting fixtures and programmable dimming features. Dedicated portable lighting units are provided in designated areas for

access and egress to areas requiring manual actions where permanently installed emergency lighting is not provided. Plant lighting fixtures are continuously energized and require no periodic testing. The self-contained eight hour battery pack emergency lighting units are periodically inspected and tested to verify proper operation including battery capacity and integrity of the charging mechanism.

Normal Lighting

The normal lighting system provides lighting in all plant indoor and outdoor areas during all modes of operation and also designs basis events, except for LOOP. The normal lighting is powered from the non-Class 1E ac power distribution system connected to the normal power supply. Lighting fixtures rated at 480/277 V are fed from 480V/277V, three phase, 4 wire, grounded neutral system lighting panels that are fed from the 480 V non-Class 1E motor control center (MCC) through dry-type 480V-480/277 V transformers. Lighting fixtures rated at 208/120V are fed from 208V/120V, three phase, four-wire, grounded neutral system distribution panels that are fed from the 480V non-Class 1E MCCs through dry-type 480V-208V/120V transformers.

Emergency Lighting

Emergency lighting is provided in the plant areas required for performing emergency tasks and safe ingress and egress of personnel during loss of normal power supply. Emergency lighting consists of (1) Class 1E emergency lighting, (2) N/E lighting, and (3) 8-hour self-contained battery pack lighting units. Class 1E emergency lighting is provided only in areas where emergency operations are required to be performed to safely shutdown the reactor, and maintain the plant in safe shutdown condition during the design basis events. The Class 1E emergency lighting system provides at least 10 foot-candles of illumination at the safety panels, workstations in the MCR and at the remote shutdown consoles. Class 1E emergency lighting is provided in the following areas: MCR, remote shutdown consoles, Class 1E emergency generator rooms, Class 1E switchgear, Class 1E MCC, Class 1E uninterruptible power supply panels, battery and battery charger rooms and access and egress routes to the remote shutdown consoles. Class 1E emergency lighting circuits in the MCR are powered from redundant Class 1E dc power. Class 1E emergency lighting in all other areas shown above is powered from the redundant Class 1E 480V MCC through a 480V-208V/120V dry-type isolating transformer. During SBO, power supply to the Class 1E 480V MCCs can be manually restored from the alternate ac power sources within 60 minutes.

N/E lighting is powered from the normal power supply, when normal power supply is available. During LOOP and SBO conditions, N/E lighting system is powered from the alternate ac power source. N/E lighting is “ON” during normal plant operation and supplements normal lighting. This system is powered from the non-Class 1E ac power distribution system. N/E lighting is powered from 208V/120V, three-phase, four-wire, grounded neutral system distribution panels fed from the 480V non-Class 1E MCC to the alternate ac power sources through dry-type 480V-208V/120V transformers. N/E lighting is not expected to be available during and after SSE conditions.

8-hour self-contained battery pack units are provided in all areas of the plant where emergency operations are performed, safe ingress and egress of personnel during emergencies are required and during loss of normal lighting. Class 1E MCCs supply power to the chargers of the self-contained battery pack units in the MCR. Non-Class

1E MCCs fed from alternate ac power sources supply power to the chargers of the self-contained battery pack units in all other non-Class 1E areas. The self-contained battery pack units provide minimum illumination of about 0.5 foot-candles at the floor level. The self-contained battery pack units located in Class 1E areas meet seismic category I requirements. Self-contained battery pack units in all other areas meet seismic category II requirements.

ITAAC: The ITAAC associated with Tier 2, Section 9.5.3 are given in Tier 1, Section 2.6.6 and Table 2.6.6-1.

TS: There are no TS for this area of review.

9.5.3.3 Regulatory Basis

The relevant requirements of the Commission regulations for this area of review, and the associated acceptance criteria, are given in Section 9.5.3 of NUREG-0800 and are summarized below. Additional guidance and review interfaces with other SRP sections also can be found in Section 9.5.3 of NUREG-0800.

No GDC or RGs directly apply to the performance requirements for the lighting system. However, the plant lighting system must have the capability to (1) provide adequate lighting during all plant operating conditions, (2) provide adequate emergency lighting during all plant operating conditions including fire, transient and accident conditions and (3) address the effect of the loss of all alternating current (ac) power (i.e., during a SBO) on the emergency lighting system. The lighting system for the US-APWR should be designed in accordance with SRP Section 9.5.3 and with lighting levels recommended in NUREG-0700, “Guidelines for Control Room Design Review,” which is based on the Illuminating Engineering Society of North America (IESNA) Lighting Handbook. The latest revision of NUREG-0700, Revision 2, “Human-System Interface Design Review Guidelines,” addresses acceptable lighting levels.

9.5.3.4 Technical Evaluation

The NRC staff reviewed the following US-APWR FSAR sections:

- Tier 1, Chapter 2, Section 2.6.6, “Lighting System”
- Tier 2, Chapter 9, Section 9.5.3, “Lighting System”

In RAI 34-780, Question 9.5.3-01, the staff asked the applicant whether aluminum lighting fixtures will be used inside containment. On May 30, 2008, the applicant stated that aluminum lighting fixtures are not used inside the containment. On the basis of its review, the staff finds that the applicant had adequately addressed the issue and, therefore, this RAI is resolved.

In RAI 34-780, Question 9.5.3-02, the staff asked the applicant to provide typical luminance ranges for normal lighting in all areas/rooms of the plant. On May 30, 2008, the applicant provided typical illumination levels in various areas/ rooms. On the basis of its review, the staff questioned whether the nominal illumination level in certain areas (e.g., TB, RB, etc.) is consistent with recommended illumination level specified in NUREG-0700. In RAI 34-780, Question 9.5.3-02 S1, the staff asked the applicant to provide justification for not following recommended illumination level specified in NUREG-0700. On September 8, 2008, the applicant stated that the nominal illumination level is consistent with recommended illumination level specified in NUREG-0700. At local control stations and areas where inspection and assembly activities are performed, additional task specific lighting would be provided to meet the illumination level requirements of IESNA and NUREG-0700. The applicant provided a modified table indicating Area/Task and Nominal Illumination Level. The staff finds that the nominal illumination level is consistent with recommended illumination level specified in NUREG-0700 and IESNA and, therefore, this RAI is resolved.

In RAI 34-780, Question 9.5.3-03, the staff asked the applicant to identify areas served by N/E lighting. On May 30, 2008, the applicant stated that N/E lighting is provided in all indoor plant areas except for the areas provided with Class 1E emergency lighting from Class 1E dc system. Typical areas provided with N/E lighting include TSC, switchgear, MCC, UPS, battery, battery charger, instrument rooms, GTG rooms, radwaste control room, stairways, aisle ways, etc. On the basis of its review, the staff finds that the applicant had adequately addressed the issue and, therefore, this RAI is resolved.

From DCD, Rev. 0, Sections 9.5.3.2.1 and 9.5.3.2.2.1, MCR lighting is 60 (50-normal and 10 Class 1E emergency) foot-candles. NUREG-0700 specifies 100 foot-candles for the MCR. In RAI 34-780, Question 9.5.3-04, the staff asked the applicant to provide an explanation for the difference. On May 30, 2008, the applicant stated that normal lighting provides 50 foot-candles on the consoles and safety panels as described in NUREG-0700, Table 12.1. Lighting at the panels is indicated as a typical value based on NUREG-0700. Normal and emergency lighting in all areas of the MCR and remote shutdown controls are designed to meet lighting in all areas of the MCR and remote shutdown controls are designed to meet all the illumination requirements of NUREG-0700. Illumination level of 100 foot-candles is provided as per NUREG-0700 in areas for hand written reading, writing material and seated operator station. The staff finds that the applicant had adequately addressed the issue, and, therefore, this RAI is resolved.

DCD, Rev. 0, Section 9.5.3.2.2.1 states that the Class 1E emergency lighting circuits in the MCR are powered from redundant Class 1E dc power. In RAI 34-780 Question 9.5.3-05, the staff asked the applicant to provide justification for not having Class 1E emergency lighting powered from redundant dc power in the RSC such that the emergency lighting in RSC is equivalent to that in the MCR. On May 30, 2008, the applicant stated that there is Class 1E emergency lighting in RSC powered from redundant Class 1E dc power. On the basis of its review the staff finds that this is a change from the DCD, Rev.0. The staff understands that this will be updated in a future DCD revision. In RAI 34-780, Question 9.5.3-05 S1, the staff asked the applicant to provide a copy of the information which will be presented in the DCD revision and identify the revision in which the change will appear. On September 8, 2008, the applicant stated that DCD, Section 9.5.3.2.2.1 will be modified to include “Class 1E emergency lighting in the MCR and RSC are powered from redundant Class 1E dc.” However, the applicant has not provided similar revision to DCD Tier 1 Section 2.6.6.1 and Table 2.6.6-1 Items 4 and 5. In RAI 80-1287, Question 9.5.3-05 S02, the staff asked the applicant to revise DCD Tier 1 Section 2.6.6.1 and Table 2.6.6-1 Items 4 and 5 to include both MCR and RSC. On November 21, 2008, the applicant stated that DCD Tier 1 Section 2.6.6.1 and Table 2.6.6-1 Items 4 and 5 will be changed to include both MCR and RSC. The staff has reviewed the changes and finds them acceptable and the RAI is resolved. **The verification that these changes are incorporated in the next DCD revision is Confirmatory Item 9.5.3-1.**

DCD, Rev. 0, Section 9.5.3.3 states that emergency lighting in the MCR is provided from Class 1E dc or ac system. Section 9.5.3.2.2.1 states that Class 1E emergency lighting circuits in the MCR are powered from redundant Class 1E dc power. In RAI 34-780, Question 9.5.3-6, the staff asked the applicant to provide clarification. On May 30, 2008, the applicant stated that emergency lighting in MCR consists of Class 1E emergency lighting powered by Class 1E dc system and emergency lighting powered by self-contained battery pack powered by Class 1E ac system. The DCD should be corrected to indicate that emergency lighting in the MCR is provided from Class 1E dc and ac system. On the basis of its review, the staff understands that this will be updated in a future DCD revision. In RAI 34-780, Question 9.5.3-06S1, the staff asked the applicant to provide a copy of the information which will be presented in the DCD revision and identify the revision in which the change will appear. On September 8, 2008, the applicant stated that DCD, Section 9.5.3.3 will be modified to include “Emergency lighting in the MCR and RSC are power from Class 1E dc and ac system.” The staff has reviewed the changes and finds them acceptable and, therefore, the RAI is resolved. The staff confirmed that DCD, Revision 2 incorporated the change discussed above.

DCD, Rev. 0, Section 9.5.3.3 states that during SBO, power supply to the Class 1E 480 V MCCs is manually restored from alternate ac power sources within 60 minutes. Section 9.5.3.2.2.2 states that the starting time of alternate ac power sources is about 100 seconds and the N/E lighting is not available during this period. In RAI 34-780, Question 9.5.3-7, the staff asked the applicant to explain why it will take 60 minutes to restore power to the Class 1E MCCs. On May 30, 2008, the applicant stated that in SBO condition, power supply to the Class 1E buses is restored manually from the AAC power source. Therefore, it may take 60 minutes to restore power to the Class 1E MCCs. On the basis of its review, the staff finds that the applicant had adequately addressed the issue and, therefore, this RAI is resolved.

Section 9.5.3.1 states that the emergency lighting circuits connected to the Class 1E power supplies are provided with Class 1E isolation devices and are non-class 1E circuits. It is not clear to the staff whether a series of circuit breakers/fuses or single circuit breaker/fuse will be used. In RAI 34-780, Question 9.5.3-8, the staff asked the applicant to address how the requirements of RG 1.75 will be met if single circuit breaker/fuse is used. Additionally, an ITAAC item shall be provided for the electrical isolation between the Class 1E ac power system and non-Class 1E lighting circuit in the MCR and RSC. On May 30, 2008, the applicant stated that single circuit breaker located in Class 1E MCC is used as the isolation device. The isolation device meets the requirements of RG 1.75. RG 1.75, Position C (1) requires analysis and periodic testing. DCD Tier 1, Table 2.6.1-3 includes an ITAAC for the item (Table 2.6.1-3, Item 3). However, the ITAAC (Table 2.6.1-3, item 3) states that an inspection of the as-built Class 1E electric power distribution equipment will be performed. The staff does not understand how RG 1.75, Position C (1) will be verified by inspection. In RAI 34-780, Question 9.5.3-08 S1, the staff asked the applicant to modify Table 2.6.1-3, item 3 to include testing (“…periodic testing of circuit breakers…during every refueling must demonstrate that the overall coordination scheme under multiple faults of nonsafety-related loads remains within the limits specified in the design criteria for the nuclear power plant.”) and analysis (the breaker time-current trip characteristics for circuit faults “under bolted or arcing fault conditions [assuming multiple faults of all nonsafety-related loads and load current of all safety-related circuits] will cause the nearest circuit breaker…to interrupt the fault current prior to initiation of a trip of any upstream protective device,”) to verify that recommendations of RG 1.75 are met. On September 8, 2008, the applicant stated that testing and analysis for isolation device will be added to the ITAAC (Table 2.6.1-3, Item 3) to verify that system meets RG 1.75. The staff understands that this will be updated in a future DCD revision. In RAI 80-1287, Question 9.5.3-08 S02, the staff asked the applicant to provide a copy of the information which will be presented in the DCD revision and identify the revision in which the change will appear. On November 21, 2008, the applicant stated that DCD Tier 1 Tables 2.6.1-3 Item 3 and Table 2.6.2-2 Item 5 will be changed to verify that the system meets RG 1.75. The staff has reviewed the changes and finds them acceptable and, therefore, the RAI is resolved. The staff confirmed that DCD, Revision 2 incorporated the changes discussed above.

DCD Tier 2, Revision 0, Section 9.5.3 contains no design description of lighting in the MCR at the safety-related panels for interior maintenance. In RAI 34-780, Question 9.5.3-9, the staff asked the applicant to provide a design description of panel lighting in the MCR or provide a technical basis for not doing so. On May 30, 2008, the applicant stated that main control console is very small and thus the inside of the main control console is not accessible to people. So there is no panel lighting in the MCR at the safety-related panels for interior maintenance. In RAI 34-780, Question 9.5.3-09 S1, the staff asked the applicant to confirm that there are no safety-related panels besides main control console in the MCR that will require lighting for maintenance. On September 8, 2008, the applicant stated that the main control console (Operator Console) in MCR consists of the console, panel, and cabinet which are safety-related. There are no safety-related panels in the MCR that will require panel lighting for interior maintenance. The staff finds that the applicant had adequately addressed the issue and, therefore, the RAI is resolved.

DCD, Tier 1, Table 2.6.6-1 is incomplete. In RAI 34-780, Question 9.5.3-10, the staff asked the applicant to include the following or provide justification for not including them: (1) DC self-contained battery pack units provide illumination of about 0.5 foot-candles at the floor level for 8-hours and (2) the emergency lighting in the MCR and remote shutdown consoles that provides illumination levels in those areas equal to greater than those recommended by the IESNA for at least eight hours. On May 30, 2008, the applicant stated that DCD, Tier 1, Table 2.6.6-1 will be revised. The staff understands that this will be updated in a future DCD revision. In RAI 34-780, Question 9.5.3-10 S1, the staff asked the applicant to provide a copy of the information which will be presented in the DCD revision and identify the revision in which the change will appear. On September 8, 2008, the applicant stated that two ITAAC will be added in DCD Revision 1, Tier 1. Under Inspection, Tests, Analyses heading for one item, the applicant stated that an inspection of the as-built DC self-contained battery pack units will be performed. The staff does not understand how the inspection will verify that DC self-contained battery pack units provide illumination of about 0.5 foot-candles at the floor level for 8-hours. In RAI 80-1287, Question 9.5.3-10 S02, the staff asked the applicant to revise the content under Inspection, Tests, Analyses for both items accordingly. Additionally, these two items should have item number 7 and 8. On November 21, 2008, the applicant stated that DCD Tier 1 Table 2.6.6-1 will be revised to include test instead of inspection and Item numbers 7 and 8 will be added. The staff has reviewed the changes and finds them acceptable and, therefore, the RAI is resolved. The staff confirmed that DCD, Revision 2 incorporated the changes discussed above.

DCD, Section 9.5.3.1 states that emergency lighting is provided in areas required for safe shutdown of the plant, restoring the plant to normal operation, firefighting and safe movement of people to the access and egress routes during plant emergencies and loss of normal power supply. In RAI 34-780, Question 9.5.3-11, the staff asked the applicant to explain how adequate lighting will be provided during an SBO event when the emergency lighting will not be available for 60 minutes. On May 30, 2008, the applicant stated that Class 1E emergency lighting from Class 1E dc power in the MCR and RSC is uninterrupted until the power supply to the Class 1E ac and dc buses is restored from the AAC GTG. Emergency lighting powered by self-contained battery packs in areas required for safe shutdown of the plant, restoring the plant to normal operation, firefighting and safe movement of people to the access and egress routes during plant emergencies is provided by the eight hour battery pack units. After restoration of power supply from the AAC GTGs within 100 seconds, N/E lighting is available. Class 1E emergency lighting from Class 1E MCCs may be available within 60-minutes. On the basis of its review, the staff finds that the applicant had adequately addressed the issue and, therefore, this RAI is resolved.

In RAI 34-780, Question 9.5.3-12, the staff asked the applicant to identify the program that will address periodic inspection and testing of self-contained 8-hour battery pack lighting units. On May 30, 2008, the applicant stated that the inspection and testing program of the self-contained 8-hour battery pack are prepared as the part of "Inservice Inspection Program" and "Inservice Testing Program" which is identified in FSAR Section 13.4. This inspection and test program will include recommended tests for emergency lighting system as delineated in Section 7.9.3 of NFPA 101, Life Safe Code. Typically, the testing program will include monthly 30 seconds functional testing and annual 8-hour capacity testing. On the basis of its review, the staff finds that the applicant had adequately addressed the issue and, therefore, this RAI is resolved.

In RAI 34-780, Question 9.5.3-13, the staff asked the applicant to explain why escape route lighting consisting of 90 minutes self-contained battery-backed sealed beam units are not used in areas such as stairwells, corridor, and exit ways. On May 30, 2008, the applicant stated that instead of 90 minutes battery pack units, 8-hour battery pack units are used in all the areas including the areas such as stairwells, corridor and building exit ways to provide sufficient time for orderly access and aggress during emergencies. On the basis of its review, the staff finds that the applicant had adequately addressed the issue and, therefore, this RAI is resolved.

The staff finds that the normal and emergency lighting systems will provide adequate lighting during normal and emergency plant operating conditions. The emergency lighting system will provide adequate station lighting in all vital areas from onsite power sources during the full spectrum of accident and/or transient conditions and to the access routes to and from these areas. The staff finds the information provided for the plant lighting system to be sufficient to meet the guidance of SRP Section 9.5.3.

9.5.3.5 Combined Licensee Information

There are no combined licensee information items related to this section.

9.5.3.6 Conclusions

Based on its review, the staff concludes that the design of the lighting system for the USAPWR conforms to the applicable staff positions and industry standards. The staff also concludes that the lighting system is in accordance with the lighting levels recommended in NUREG-0700, which is based on the IESNA Lighting Handbook. Therefore, the staff finds that the subject design is acceptable.

9.5.4 Gas Turbine Generator Fuel Oil Storage and Transfer System (Related to RG 1.206, Section C.III.1, Chapter 9, C.I.9.5.4, “Diesel Generator Fuel Oil Storage and Transfer System”)

9.5.4.1 Introduction

The review of the Class 1E emergency GTG fuel oil storage and transfer system (EGTFSS) is to assure compliance with the requirements of GDCs 2, 4, 5, and 17, by all piping up to the connection to the engine interface, the fuel oil storage tanks, the fuel oil transfer pumps, day tanks, and the tank storage vaults. In addition, the review covers the quality and the quantity of fuel oil stored onsite and the availability and procurement of additional fuel from offsite sources.

The US-APWR reactor design provides GTGs in lieu of diesel engine generators to perform the standby emergency power supply function required by GDC 17, Electric Power Systems. The Standard Review Plan (NUREG-0800) does not include guidance for emergency GTG support systems. However, the staff used the guidance in SRP Section 9.5.4, to the extent applicable, for the review and safety evaluation report preparation for this section of the US-APWR DCD. In addition, the staff considered the information in Interim Staff Guidance Document ISG-021, "Interim Staff Guidance on the Review of Nuclear Power Plant Designs using a Gas Turbine Driven Standby Emergency Alternating Current Power System" (ISG-021), to inform the staff's review and safety evaluation report. The applicant states in DCD Tier 2 Table 1.9.2-9 that the US-APWR design conforms to SRP Section 9.5.4 with no exception.

Each of the four redundant Class 1E emergency power supplies, referred to as a GTG, is a skid-mounted, enclosed package consisting of two gas turbines operating in parallel to drive a single generator through a gearbox.

9.5.4.2 Summary of Application

DCD Tier 1: The Tier 1 information associated with this section is found in Tier 1, Section 2.6.4 and Table 2.6.4-1.

DCD Tier 2: The applicant has provided a Tier 2 description in Section 9.5.4, summarized here in part as follows:

> The US-APWR's EGTFSS provides storage and continuous supply of fuel oil to each of the four Class 1E emergency GTGs, to safely shut down the plant and maintain a safe shutdown condition following a DBA concurrent with a LOOP. Each GTG is supplied by a fuel oil storage tank and a fuel oil day tank, which store ASTM D975 diesel grade No. 2-D fuel (fuel oil). Each fuel oil storage tank provides seven days storage of fuel oil at the design basis load conditions. This allows power to be supplied to the safety-related loads for postulated accident conditions, assuming the loss of all offsite power sources and an additional amount for periodic testing of the onsite power sources. Each GTG has two fuel oil transfer pumps and a fuel oil day tank with a capacity to supply sufficient fuel oil for a period of 1.5 hours at the design basis load conditions.
>
> The EGTFSS is designed so that a single failure of any component, assuming a loss of offsite power, cannot result in complete loss of the emergency power source. A description of the system, the design basis, and design parameters are presented in the US-APWR DCD, including a simplified system diagram as well as inspection and testing requirements for the GTG fuel oil.

ITAAC: The ITAAC associated with Tier 2, Section 9.5.4 are given in Tier 1, Section 2.6.4 and Table 2.6.4-1.

TS: DCD Tier 2, Chapter 16, TS 3.8.1, "AC Sources—Operating," provides EDG requirements SRs 3.8.1.4 through 3.8.1.6, 3.8.3.1, 3.8.3.3., and 3.8.3.5 provide day tank, storage tank and transfer pump requirements. Limiting Conditions for Operation for the DGFOSTS are given in Chapter 16, LCO 3.8.3, "Class 1E Gas Turbine Generator Fuel Oil, Lube Oil, and Starting Air."

In addition, TS 5.5.13, “Gas Turbine Generator Fuel Oil Testing Program,” provides requirements for a program to ensure the quality of the diesel fuel oil.

9.5.4.3 Regulatory Basis

The relevant requirements of the Commission regulations for this area of review, and the associated acceptance criteria, are given in Section 9.5.4 of NUREG-0800 and are summarized below. Further guidance and review interfaces with other SRP sections also can be found in Section 9.5.4.I of NUREG-0800.

1. GDC 2, “Design Bases for Protection Against Natural Phenomena,” as it relates to SSCs that must be protected from, or be capable of withstanding, the effects of natural phenomena like earthquakes, tornadoes, hurricanes, and floods as established in DCD Chapters 2 and 3.

2. GDC 4, “Environmental and Dynamic Effects Design Bases,” as it relates to SSCs that must be protected from, or be capable of withstanding the effects of, externally- and internally-generated missiles, pipe whip, and jet impingement forces associated with pipe breaks.

3. GDC 5, “Sharing of Structures, Systems, and Components,” as it relates to the capability of systems and components important to safety shared between units to perform required safety functions.

4. GDC 17, “Electric Power Systems,” as it relates to capability to meet independence and redundancy criteria.

5. 10 CFR 52.47(b)(1), which requires that a DC 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 DC is built and will operate in accordance with the DC, the provisions of the Atomic Energy Act, and the NRC’s regulations.

Acceptance criteria adequate to meet the above requirements include:

1. Regulatory guidance for the GTG fuel oil storage and transfer system design, fuel quality, and tests are specified in RG 1.137, “Fuel-Oil Systems for Standby Diesel Generators,” Regulatory Positions C.1 and C.2. Position C.1 addresses materials, physical arrangement, and applicable codes and regulations. RG 1.137 was issued in October 1979 and, consequently, the referenced standards have been replaced and/or updated. The applicant has committed to a design in accordance with the updated or replacement versions of the standards referenced in the RG. The quality of fuel oil is determined by performing suitable tests defined in the standards and the fuel oil is replaced when it does not meet the acceptance criteria in the standards.

2. NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability," provides some guidance based on operating experience that can be applicable to GTGs.

3. ANSI/ANS-59.51-1997, "Fuel Oil Systems for Safety-Related Emergency Diesel Generators," regarding the onsite fuel oil storage and transfer for each of the four redundant emergency power supplies being sufficient to support operation of the emergency power supply following any design basis event and a continuous loss of off-site power either for seven days, or for the time required to replenish the fuel from sources outside the plant site following any design event without interruption of the operation of the emergency power supply, whichever is longer.

9.5.4.4 Technical Evaluation

The staff has reviewed the EGTFSS as presented in the DCD submitted in March 2011 (Revision 3). This review also considered the relevant portions of the "Qualification and Test Plan of Class 1E Gas Turbine Generator System," October 2010 (MUAP-07024-P(R2)), which was submitted by MHI, and is referenced in the DCD in Section 8.3.1. The staff directed its evaluation to determine whether the EGTFSS design complies with the requirements of GDC 2, 4, 5, and 17 and 10 CFR 52.47(b)(1). The EGTFSS stores and supplies fuel oil for operation of the Class 1E GTGs which are required to safely shut down the plant and maintain a safe shutdown condition following a DBA concurrent with a LOOP by supplying power to essential loads. Each GTG is supplied by a fuel oil day tank that is fed by redundant fuel oil transfer pumps from a fuel oil storage tank.

Section 9.5.4.2 of Tier 2 of the US-APWR DCD provides a system description of the EGTFSS. Staff acceptance of the US-APWR EGTFSS is based on meeting the regulatory basis for this system as follows:

A. GDC 2, "Design Bases for Protection Against Natural Phenomena"

GDC 2 requires that the EGTFSS be protected from, or be capable of withstanding the effects of natural phenomena. Portions of the system important to safety are housed within Seismic Category I structures. Each of the four GTG fuel oil storage tanks is contained in a separate, reinforced concrete Seismic Category I, missile-protected, flood-protected underground compartment. Additionally each GTG is located in a separate Seismic Category I compartment.

The EGTFSS is designed in accordance with Seismic Category I requirements as specified in US-APWR DCD Section 3.2. According to US-APWR DCD, systems, equipment and components which are not Seismic Category I and whose failure could impair the functioning of the EGTFSS are upgraded to Seismic Category I. When Seismic Category I components are not available, and failure of those components could impair the functioning of the system, the components used are proven to be of equivalent quality through design and/or testing.

Each GTG room contains a single GTG. The GTG rooms are separated by fire-rated barriers such that a fire in one GTG room will not impact more than one GTG. The fuel oil day tank for each GTG is located in the respective GTG room and is surrounded by a dike with sufficient capacity to hold 110 percent of the day tank contents.

Each of the four fuel oil storage tank underground vaults is designed to withstand hurricane and tornado related damages and the systems are safe from the effects of flooding as described in Section 3.3 and 3.5 of the US-APWR DCD. The fuel oil fill and vent lines for the fuel oil storage tanks terminate above the design basis flood level. The fill line is capped and locked and has a locked closed isolation valve.

Therefore the NRC staff finds that the EGTFSS meets the requirements of GDC 2.

B. GDC 4, "Environmental and Dynamic Effects Design Bases"

GDC 4 requires that the EGTFSS must be protected from, or be capable of withstanding the effects of, externally- and internally-generated missiles, pipe whip, and jet impingement forces associated with pipe breaks.

DCD Tier 2 Section 3.5 states that the GTGs are considered potential sources of missile generation. However, missiles generated within the GT are not postulated by the applicant because of an over-speed prevention system and the casing that prevents penetration. The power section of the gas turbine is designed so that the capacity of the casing to absorb energy is greater than the kinetic energy of rotational parts of the turbine. Missiles are not postulated to be generated by the GTG.

The dynamic effects associated with postulated rupture of piping are addressed in Chapter 3 of the US-APWR DCD. Since each GTG, including its support systems, is located in a separate Seismic Category I structure, rupture of any piping within one GTG room will not impact the operation of the redundant GTGs.

Therefore the NRC staff finds that the EGTFSS meets the requirements of GDC 4.

C. GDC 5, "Sharing of Structures, Systems, and Components"

GDC 5 requires that SSCs important to safety must not be shared among nuclear units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions.

The US-APWR design can be used at either single-unit or multiple-unit sites. Nonetheless, in Table 1.9.1-1 it is stated that "DCD describes a single reference plant design." This is also discussed in DCD Tier 2, Section 3.1.1.5. Should a multiple-unit site be proposed, the combined license applicant referencing the US-APWR design will be required to apply for the evaluation of compliance with the requirements of GDC 5, with respect to the capability of shared SSCs important to safety to perform their required safety functions. Consequently, GDC 5 does not apply to the US-APWR design as described in the DCD.

D. GDC 17, "Electric Power Systems"

Provisions shall be included to minimize the probability of losing electric power required for safe shutdown, including provisions for an onsite emergency power supply that meets the required independence and redundancy criteria. The EGTFSS must have the capability to meet independence and redundancy criteria.

An approved industry standard for the design of gas turbines is ISO 3977 "Gas Turbine Procurement Part 3 Design Requirements," 2004. The US-APWR DCD does not reference this standard for the emergency GTGs. Therefore the staff has requested the applicant in **RAI 468-3360, Question 9.5.4-49** to add this standard as a design basis for the US-APWR GTGs and identify and justify any deviations from this standard. As an alternative, the applicant may propose some other appropriate industry standard that is specific to the type of GTGs proposed for the US-APWR and address any deviations. The resolution of this RAI will be tracked as **Open Item 9.5.4-1.** This standard is applicable to all of the emergency GTG support systems and the applicant's commitment should apply to all of the support systems.

Each fuel oil storage tank is designed for a seven-day supply to its associated GTG, without relying on the associated fuel oil day tank inventory, plus a margin for periodic testing of the GTG. The fuel extraction point is six inches above the tank bottom to minimize the amount of sediment entering the fuel line as recommended by NUREG-0660. RG 1.137 references an industry standard as providing appropriate guidance to calculate the required storage capacity of fuel oil for a seven-day supply. The guidance in RG 1.137 is applicable to the US-APWR emergency GTGs. RG 1.137 has not been updated since 1979 and the industry standard identified in this RG as providing acceptable guidance for sizing the fuel oil storage tanks has been replaced by ANSI/ANS-59.51-1997, "Fuel Oil Systems for Safety-Related Emergency Diesel Generators." US-APWR DCD Tier 2 Section 9.5.4.1 states that the EGTFSS is in accordance with ANSI/ANS-59.51-1997.

The applicant has demonstrated compliance with ANSI/ANS-59.51-1997 by submitting a table for NRC staff review that compares the guidance of the standard with the US-APWR EGTFSS design. Where appropriate, the design was revised to be consistent with the standard's guidance and changes were made to the US-APWR DCD to summarize compliance with this standard.

DCD Tier 2 Section 9.5.4.3 states that the piping between the underground storage tank and the GTG building is routed in concrete pipe chases. The piping is welded to prevent leakage and the chases will permit access for inspection of the piping. In addition, adequate space is provided around the storage tanks to permit inspection of the tanks.

The fuel oil storage tanks are designed to ASME Boiler and Pressure Vessel Code, "Section III, Division 1, Subsection ND, Class 3 Components." Each fuel oil storage tank includes a vent line, including a flame arrestor, and a level transmitter. As described in DCD Section 9.5.4, the applicant has taken several steps to minimize the effects of accumulated sediment in the storage tanks. Each fill line includes duplex filters and a moisture separator. The fill connection includes an internal pipe and diffuser to reduce fill velocities and turbulence that would stir up sediment. The outlet connections are six inches above the bottom of the tank, so that sediment cannot flow directly into the outlet pipe. These arrangements help to satisfy the requirement in RG 1.137 (Section C.2.g) that refueling the tank should not stir up bottom sediment. Duplex strainers are provided on the tank outlet flow line to the fuel oil transfer pumps and a duplex filter is provided at the discharge of the transfer pumps. The vent and fill lines terminate above the flood level. The fill and sample lines are located at grade with locked-closed isolation valves and are capped and locked.

The tanks themselves are covered (outside and inside) with primer and finish coat to control corrosion. This should reduce sediment in the tanks and is consistent with the recommendation in RG 1.137, Section C.1.g. ASTM D975 states that materials or coatings containing Cu or Zn could enhance deterioration of fuel and promote gel formation. The US-APWR DCD states that no tank materials or interior coatings will contain Cu or Zn.

A fuel oil storage tank aggregate sample point is provided from the top of the tank within the tank enclosure to sample the fuel oil, including sediments and water. The sample points are shown on Figure 9.5.4-1 of the US-APWR DCD. It was not clear, however, how the contents of the tank can be sampled from a connection at the top of the tank without some means of lifting the oil. Therefore the staff requested the applicant in RAI 468-3360, Question 9.5.4-45 to describe the means of sampling the tank's contents. In response to this RAI dated December 11, 2009, the applicant provided a revised Figure 9.5.4-1, showing the sample connection extending outside of the fuel oil storage tank vault and the applicant described the method for obtaining a fuel oil sample from the bottom of the fuel oil storage tank using a 300 ml sample head and a multi-section shaft. The RAI response is acceptable, and since the revisions to Figure 9.5.4-1 were made to Revision 3 of the US-APWR DCD, this issue is considered resolved.

The fuel oil day tank elevation is specified to provide the necessary suction head for the GTG fuel oil pumps. The fuel flows by gravity into the GTG unit. These features conform to the acceptance criteria of SRP Section 9.5.4. Each fuel oil day tank feeds two GTs (there are two GTs per GTG). The supply pipe from the storage tank to each set of pumps connects to the pump suction header at the midpoint between the two pumps to ensure balanced flow and pressure for both on-engine pumps.

The fuel oil transfer piping is located away from hot surfaces. Tank fittings are provided for water removal, vent connection, and instrumentation. The fuel oil day tank vent includes a flame arrestor. Both the storage and the day tanks include level instrumentation that activates alarms in the MCR upon a low or high level signal. These features conform to the acceptance criteria of SRP Section 9.5.4.

The fuel oil specification is in accordance with ASTM D975. Biocides and other fuel additives are used to prevent deterioration of the oil, accumulation of sludge, and the growth of algae and fungi. Such additives are not mentioned in RG 1.137 or in ANSI N195-1976; biocides are mentioned in ASTM D975, and are acceptable, but not required. The applicant does not plan to use alternative fuels for the emergency GTGs.

As described in US-APWR DCD Section 9.5.4.3, the fuel oil is sampled periodically for specific gravity, water, sediment, viscosity, contamination, and algae. Specific details of this sampling process and corrective actions are described in the TS (DCD Chapter 16). The frequency of checking for and removing accumulated water in storage tanks is set at 31 days (SR 3.8.3.5), consistent with RG 1.137 (Section C.2.e). In response to RAI 317-2061, Question 9.5.4-2, the applicant has stated that TS Bases for SR 3.8.1.5 (day tanks) and TS 3.8.3 Condition F (supply tanks) indicate that water will be removed immediately if found during the course of surveillance, and would thus avoid a declaration that the GTG was inoperable. The only fuel oil property with a required time frame for corrective action in the TS is particulate level (Ch. 16, p. B 3.8.3-4, Action C.1), for which one week is allowed for correction, consistent with RG 1.137 (C.2.a). In response to RAI 317-2061, Question 9.5.4-2, the applicant noted that Programs and Manuals Section 5.5.13 (DCD Chapter 16) states that "…total particulate concentration of the fuel oil is ≤ 10 mg/L when tested every 31 days." This plan provides for more stringent requirements than those of ANSI N195-1976 (Appendix B) which require a particulate concentration of ≤ 20 mg/L and sampling frequency at least quarterly.

The DCD does not mention sampling frequencies for other parameters such as specific gravity, viscosity, contamination, and algae in storage tanks and day tanks, although frequencies for these are not included in regulatory requirements. In TS 3.8.3 D.1, the applicant specifies a 30-day period for correction of stored fuel oil properties (other than water and sediment) to within limits, while the time mentioned in RG 1.137 C.2.e for correcting most deficiencies is "…a short period of time (about one week)." It is obvious from the wording that this time limit is only approximate, and maintaining these fuel oil properties can involve site-specific procedures. As noted in the response to RAI 317-2061, Question 9.5.4-2, the TS Bases D.1 implies that new fuel oil will not be added to supply tanks unless testing verifies that the resulting mix of old and new fuel oil will properly meet specifications. Therefore, RAI 317-2061, Question 9.5.4-2 is resolved.

The sampling procedure for new fuel oil in the US-APWR DCD (Chapter 16, p. B 3.8.3-6) follows ASTM D4057, consistent with the recommendations in ASTM D975. The acceptable values for specific gravity or API gravity, kinematic viscosity, and flash point are exactly those of ASTM D975. The tests performed on the new fuel described in Programs and Manuals Section 5.5.13 are consistent with those recommended by RG 1.137 C.2.b, with the exception of the test for water and sediment. In TS 5.5.13, the applicant mentions a visual inspection for clear and bright appearance, but does not mention the centrifugation test of ASTM D2709. The NRC staff requested clarification of this testing procedure in RAI 317-2061, Question 9.5.4-3 and RAI 467-3609, Question 9.5.4-43. Because RG 1.137 specifically references ASTM D975, and the only procedure cited therein is the centrifugation method in ASTM D2709, the staff does not accept the approximate visual method of ASTM D4176 without further justification explaining why it provides an acceptable alternative to the centrifugation test of ASTM D2709. In the response to RAI 467-3609, Question 9.5.4-43, the applicant has declared that they will follow the centrifugal testing procedure as outlined in ASTM D2709, consistent with the directives in ASTM D975, and that the DCD would be modified accordingly. This RAI response is acceptable, and since it has been incorporated into US-APWR DCD Revision 3, this issue is resolved. In response to RAI 317-2061, Question 9.5.4-4, the applicant has confirmed their intentions to use the latest revisions of these standards or replacement standards, which is consistent with best practice and meets the intent of the applicable regulatory guidance, as discussed in Section 9.5.4.1 above. Therefore, RAI 317-2061, Questions 9.5.4-3, -4, and RAI 467-3609, Question 9.5.4-43 are resolved.

Fuel sample testing in accordance with ASTM D975 includes measurement of the cloud point temperature to verify that it remains below the required value. The fuel oil will be maintained above the cloud point temperature by an area electric heater in the fuel oil storage tank vault, if required by site design conditions. Fuel oil temperature will be monitored in the storage tank and the heater will operate automatically as required to maintain oil temperature above the cloud point.

The guidance in RG 1.137 (C.2.f) includes removal of fuel oil and tank cleaning at least every ten years. US-APWR DCD Section 9.5.4.3 describes a plan for cleaning day and storage tanks at least every 10 years.

Each set of EGTFSS pumps is mounted on a skid and is powered from the respective Class 1E power bus. The fuel oil transfer pumps start and stop upon receipt of low and high level signals from the day tank. Per DCD Tier 2 Section 9.5.4.2.1, bulk fuel storage tanks are located in protected compartments. Section 9.5.4.2.2.2 describes the fuel oil transfer pumps as components on modularized skids. DCD Tier 2 Table 9.5.4-1 indicates that the fuel oil transfer pumps are designed to operate with a flooded suction.

Therefore the NRC staff finds that the EGTFSS meets the requirements of GDC 17.

ITAAC: ITAAC items specific to the emergency power sources are listed in DCD Tier 1 Table 2.6.4-1. The items related to the EGTFSS are as follows:

- Item 1 requires an inspection to verify that the as-built GTG system is functionally consistent with the description in DCD Section 2.6.4.1.

- Item 3 requires an inspection to ensure that each independent GTG has its own dedicated fuel, oil supply and transfer, lubrication, starting, and combustion air intake and exhaust systems.

- Item 4 requires an inspection and test to verify that each emergency GTG support system is provided power by the same division of the Class 1E power system as the respective emergency GTG.

- Item 7 requires hydrostatic tests be performed on the as-built components and piping of the EPS support systems as required by ASME Section III. This includes verification that ASME Code Data Reports have been completed and are in the plant records.

- Item 8 requires inspections and type tests, analyses or a combination of type tests and analyses to verify that the Seismic Category I EPS support system equipment and piping, including supports, can withstand seismic design basis loads without loss of safety function.

- Item 12 requires an inspection and test to ensure that each GTG system is independent of the other GTG systems and each of the four GTGs is located in a separate room of the PS/B. Rev 3 of Tier 1 of the US-APWR DCD replaced the statement that "Each Class 1E EPSs are located in a separate room in the PS/B" with the statement that "The Class 1E EPSs are located in separate rooms in the PS/B." This new statement in 12.b should similarly make it clear that each Class 1E EPS train is located in a separate room of the PS/B. This comment also applies to the description in Tier 1, Table 2.6.4-1, Item 12.b. Therefore the staff requested the applicant in RAI 5617, Question 14.3.6-20 to revise the wording of this ITAAC to clarify the design. The applicant responded on July 15, 2011, that Tier 1, Table 2.6.4-1, ITAAC Item 12.b, Design Commitment, will be revised to state that "Each redundant division of Class 1E EPSs is located in a separate room of the PS/B." The corresponding ITAAC Acceptance Criteria and Section 2.6.4.1 will be similarly revised. The staff finds the RAI response to be acceptable and considers RAI 5617, Question 14.3.6-20 to be closed. The inclusion of the proposed changes described in the response to RAI Question 14.3.6-20 is being tracked as **Confirmatory Item 9.5.4-1**.

- Item 19 requires an inspection to ensure that the as-built EGTFSS is as described in DCD Tier 1 Section 2.6.4.2.

- Item 21 requires an inspection and tests to ensure that each fuel oil transfer pump transfers fuel from the oil storage tank to the day tank at a rate to support operation of the respective GTG at continuous rated load while simultaneously increasing day tank level. These tests will also verify that adequate fuel oil transfer pump NPSH is maintained under all design conditions.

- Item 22 requires an analysis and inspection to verify that the day tank capacity is sufficient to provide 1.5 hours of EPS operation at rated load and that the as-built day tank's capacity bounds the analysis.

- Item 23 requires inspections to be performed to verify retrievability of the alarms provided in the MCR as described in DCD Section 2.6.4.2 for the as-built EGTG support systems.

- Item 24 requires a test to verify that the fuel oil transfer pump stars automatically on a fuel oil day tank low level signal and stops automatically on a fuel oil day tank high level signal.

- Item 25 requires a test to ensure that each fuel oil pump is powered by the same Class 1E division as the corresponding GTG.

- Item 26 requires inspections and reconciliation analyses to verify that the ASME Section III components and piping (including piping supports) of the as-built emergency GTG support systems are designed, fabricated, installed and inspected in accordance with ASME Section III requirements and that all required ASME documentation is provided.

- Item 27 requires non-destructive examination of the as-built pressure boundary welds for ASME Section III components and piping and verification that all required ASME documentation is provided.

- Item 29 requires an analysis to determine the required fuel oil storage tank volume to provide a seven day supply of fuel oil to its respective Class 1E EPS and an inspection of the as-built tank to verify that the capacity bounds the analysis.

TS and Initial Plant Test Program: TS surveillance testing and inspection of the EGTFSS is performed to assure operational readiness, as described in DCD Tier 2 Chapter 16. Periodic sampling of the fuel oil quality in the fuel oil storage tank is required. The staff finds the US-APWR TS requirements for the EGTFSS are consistent with applicable NRC standard TS and are considered acceptable.

The EGTFSS is tested prior to initial startup. Preoperational testing is described in DCD Tier 2 Section 14.2.12.1.44. Each test of system operation will test the EGTFSS operation. System performance is verified during periodic GTG testing. Inspection of piping is performed in accordance with the requirements of ASME Section XI, as discussed in DCD Tier 2 Section 6.6. The tests described in the DCD for the EGTFSS are acceptable to the staff.

9.5.4.5 Combined License Information Items

The following Combined License Information Item is described in US-APWR DCD Tier 2, Revision 3, Section 9.5.9 for the EGTFSS. This COL Information Item was added in response to RAI 9.5.4-44 and the RAI response is acceptable.

Table 9.5.4-1
US-APWR Combined License Information Items

Item No.	Description	Section

COL 9.5(12)	*The COL applicant is to address the need for installing unit heaters in the Power Source Fuel Storage Vault during winter for site locations where extreme cold temperature conditions exist.*	9.5.9

In addition, COL item 3.7(12) requires the COL applicant to design the Seismic Category I storage tanks. The staff finds these COL items to be acceptable and complete. No other COL items were identified for the EGTFSS.

9.5.4.6 Conclusions

The NRC staff concludes that, pending resolution of **RAI 468-3360, Question 9.5.4-49, Open Item 9.5.4-1; and the closure of Confirmatory Item 9.5.4-1** the emergency GTG fuel oil storage and transfer system design is acceptable and complies with regulations as stated in the general design criteria of Appendix A to 10 CFR Part 50, as well as 10 CFR 52.47(b)(1). Pending resolution of the RAIs, this conclusion is based on the technical evaluation that determined the DCD meets GDC 2, GDC 4, GDC 5, GDC 17, and 10 CFR 52.47(b)(1).

9.5.5 Gas Turbine Generator Cooling System

9.5.5.1 Introduction

The US-APWR reactor design provides GTGs in lieu of diesel engine generators to perform the standby emergency power supply function required by GDC 17, Electric Power Systems. The applicant states in DCD Tier 2 Table 1.9.2-9 that SRP Section 9.5.5 is not applicable to the US-APWR emergency power supply because the GTGs have no functional equivalent of a cooling water system. The GTGs are air-cooled and this cooling function is evaluated in SER Sections 9.5.7 and 9.5.8.

9.5.5.2 Summary of Application

US-APWR DCD Tier 2, Section 9.5.5, states that the GTG cooling water system is not required and references DCD Section 9.5.8 for a description of the air ventilation system that provides the GTG cooling function.

ITAAC: ITAAC items specific to the cooling functions of the GTGs are addressed in Sections 9.5.7 and 9.5.8 of the SER.

TS and Initial Plant Test Program: The TS are presented in Section 16 of the DCD Tier 2 document. The staff’s technical evaluation of the of the cooling functions of the GTGs is described in Sections 9.5.7 and 9.5.8 of this SER.

9.5.5.3 Regulatory Basis

The relevant requirements of the Commission regulations for this area of review, and the associated acceptance criteria, are given in Section 9.5.7 and 9.5.8 of NUREG-0800 and are addressed in SER Sections 9.5.7 and 9.5.8.

9.5.5.4 Technical Evaluation

The staff has reviewed the US-APWR's GTG description, as presented in the DCD submitted in March 2011 (Revision 3). This review also considered the relevant portions of the "Qualification and Test Plan of Class 1E Gas Turbine Generator System," October 2010 (MUAP-07024-P(R2)), which was submitted by MHI, and is referenced in the DCD in Section 8.3.1. DCD Tier 2 Section 9.5.5 states that the GTG does not need cooling water and that cooling of the GTG is achieved by the air ventilation system described in DCD Tier 2 Section 9.5.8.

The staff directed its evaluation to determine whether the US-APWR GTGs require a cooling water system to perform the standby emergency power supply function. Cooling for the GTGs is provided by two systems. The first is a building ventilation system which draws ventilation/cooling air into each GTG room. Cooling air for the GTG is drawn from the room and exhausted through the roof of the building. The design of the ventilation/cooling system is presented in DCD Tier 2 Section 9.5.8. The second is a lubrication oil air-cooled radiator to maintain the lubrication oil within operational limits, which is presented in DCD Tier 2 Section 9.5.7. The staff's technical evaluation for these cooling systems is described in Sections 9.5.7 and 9.5.8 of the SER.

9.5.5.5 Combined License Information Items

Any COL Information Items pertaining to the GTG cooling functions will be identified in DCD Tier 2, Sections 9.5.7 and 9.5.8.

9.5.5.6 Conclusions

Based on the staff's technical review of the US-APWR GTG description provided in the US-APWR DCD, the staff concludes that a separate cooling water system is not required for the US-APWR GTGs, as stated in the DCD. The staff's evaluation of the cooling functions required for the GTGs is included in SER Sections 9.5.7 and 9.5.8.

9.5.6 Gas Turbine Generator Starting System (Related to RG 1.206, Section C.III.1, Chapter 9, C.I.9.5.6, "Diesel Generator Starting System")

9.5.6.1 Introduction

The review of the Class 1E emergency GTG starting system (EGTSS) includes system features necessary for reliable starting following a loss of offsite power to assure compliance with the requirements of GDCs 2, 4, 5, and 17. The review includes the system air compressors, air dryers, air receivers, devices to start the turbines, valves, piping, filters, and ancillary instrumentation and control systems.

The US-APWR reactor design provides GTGs in lieu of diesel engine generators to perform the standby emergency power supply function required by GDC 17, Electric Power Systems. The Standard Review Plan (NUREG-0800) does not include guidance for emergency GTG support systems. However, the guidance in SRP Section 9.5.6 is used to the extent applicable for the review and safety evaluation report preparation for this section of the US-APWR DCD. In addition, the staff considered the information in Interim Staff Guidance Document ISG-021, "Interim Staff Guidance on the Review of Nuclear Power Plant Designs using a Gas Turbine Driven Standby Emergency Alternating Current Power System" (ISG-021), to inform the staff's review and safety evaluation report. The applicant states in DCD Tier 2 Table 1.9.2-9 that the US-APWR design conforms to SRP Section 9.5.6 with no exception.

Each of the four redundant Class 1E emergency power supplies, referred to as a GTG, is a skid-mounted, enclosed package consisting of two gas turbines operating in parallel to drive a single generator through a gearbox.

9.5.6.2 Summary of Application

DCD Tier 1: The Tier 1 information associated with Tier 2 Section 9.5.6 is found in Tier 1, Section 2.6.4 and Table 2.6.4-1.

DCD Tier 2: The applicant has provided a Tier 2 description in Section 9.5.6, summarized here in part as follows. Each GTG has its own independent starting air system.

> The US-APWR's EGTSS initiates a start of the GTG so that within 100 seconds after receipt of the start signal, the GTG is operating at rated speed and is ready to begin load sequencing. The GTG starting system is an air-powered system, and contains sufficient stored compressed air to start the GTG three times. The EGTSS provides starting air to each of the four Class 1E emergency GTGs, to safely shut down the plant and maintain a safe shutdown condition following a DBA concurrent with a LOOP.
>
> The applicant states that, except for the air compressors with air coolers and piping up to the inlet check valve of the starting air receivers, the starting system is designed in accordance with Seismic Category I requirements and to the requirements of ASME Boiler & Pressure Vessel Code, Section III, Class 3. The nonsafety-related air compressors and coolers are designed to manufacturers' standards and are pressure tested.
>
> The EGTSS is designed so that a single failure of any component, assuming a loss of offsite power, cannot result in complete loss of the emergency power source. A description of the system, the design basis, and design parameters are presented in the US-APWR DCD, including a simplified system diagram.

ITAAC: The inspections, tests, analyses, and acceptance criteria (ITAAC) associated with Tier 2, Section 9.5.6 are given in Tier 1, Section 2.6.4 and Table 2.6.4-1.

TS: The TS associated with DCD Tier 2, Section 9.5.6 are given in DCD Tier 2, Chapter 16, Section 3.8.1, "AC Sources – Operating" and Section 3.8.3, "Class 1E Gas Turbine Generator Fuel Oil, Lube Oil, and Starting Air."

The EGTSS is tested prior to initial startup. Preoperational testing is described in DCD Tier 2 Section 14.2.12.1.44. Each test of system operation will test the EGTSS operation. System performance is verified during periodic GTG testing. Inspection of piping is performed in accordance with the requirements of ASME Section XI, as discussed in DCD Tier 2 Section 6.6.

9.5.6.3 Regulatory Basis

The relevant requirements of the Commission regulations for this area of review, and the associated acceptance criteria, are given in Section 9.5.6 of NUREG-0800 and are summarized below. Further guidance and review interfaces with other SRP sections also can be found in Section 9.5.6.I of NUREG-0800.

1. GDC 2, “Design Bases for Protection Against Natural Phenomena,” as it relates to SSCs that must be protected from, or be capable of withstanding, the effects of natural phenomena like earthquakes, tornadoes, hurricanes, and floods as established in DCD Chapters 2 and 3.

2. GDC 4, “Environmental and Dynamic Effects Design Bases,” as it relates to SSCs that must be protected from, or be capable of withstanding the effects of, externally- and internally-generated missiles, pipe whip, and jet impingement forces associated with pipe breaks.

3. GDC 5, “Sharing of Structures, Systems, and Components,” as it relates to the capability of systems and components important to safety shared between units to perform required safety functions.

4. GDC 17, “Electric Power Systems,” as it relates to capability to meet independence and redundancy criteria.

5. 10 CFR 52.47(b)(1), which requires that a DC 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 DC is built and will operate in accordance with the DC, the provisions of the Atomic Energy Act, and the NRC’s regulations.

Acceptance criteria adequate to meet the above requirements include:

> NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability," provides some guidance based on operating experience that can be applicable to GTGs. Also, each GTG should have a dedicated starting air system consisting of a compressor, an air dryer, and one or more receivers as recommended by the engine manufacturer.

9.5.6.4 Technical Evaluation

The staff has reviewed the EGTSS as presented in the DCD submitted in March 2011 (Revision 3). This review also considered the relevant portions of the “Qualification and Test Plan of Class 1E Gas Turbine Generator System,” October 2010 (MUAP-07024-P(R2)), which was submitted by Mitsubishi Heavy Industries, and is referenced in the DCD in Section 8.3.1. The staff directed its evaluation to determine whether the EGTSS design complies with the requirements of GDC 2, 4, 5, and 17 and 10 CFR 52.47(b)(1). The EGTSS starts the Class 1E GTGs which are required to safely shut down the plant and maintain a safe shutdown condition following a DBA concurrent with a LOOP by supplying power to essential loads.

Section 9.5.6.2 of Tier 2 of the US-APWR DCD provides a system description of the EGTSS. Staff acceptance of the US-APWR EGTSS is based on meeting the Regulatory Basis for this system as follows:

A. GDC 2, “Design Bases for Protection Against Natural Phenomena”

GDC 2 requires that the EGTSS be protected from, or be capable of withstanding the effects of natural phenomena. Portions of the system important to safety are housed within Seismic Category I structures. Additionally each GTG and its associated EGTSS is located in a separate Seismic Category I compartment.

The EGTSS is designed in accordance with Seismic Category I requirements as specified in US-APWR DCD Section 3.2. The EGTSS air receivers and safety-related piping, fittings and valves are rated Seismic Category I. Systems, equipment and components which are not Seismic Category I and whose failure could impair the functioning of the EGTSS are upgraded to Seismic Category I.

Protection from tornadoes, hurricanes and floods is provided by the GTG enclosure building as described in Chapter 3 of the DCD. Each GTG and its associated EGTSS is located in a separate Seismic Category I compartment.

Therefore the NRC staff finds that the EGTSS meets the requirements of GDC 2.

B. GDC 4, “Environmental and Dynamic Effects Design Bases”

The EGTSS must be protected from, or be capable of withstanding the effects of, externally- and internally-generated missiles, pipe whip, and jet impingement forces associated with pipe breaks.

DCD Tier 2 Section 3.5 states that the GTGs are considered potential sources of missile generation. However, missiles generated within the GT are not postulated by the applicant because of an over-speed prevention system and the casing that prevents penetration. The power section of the gas turbine is designed so that the capacity of the casing to absorb energy is greater than the kinetic energy of rotational parts of the turbine. Missiles are not postulated to be generated by the GTG.

The dynamic effects associated with postulated rupture of piping are addressed in Chapter 3 of the US-APWR DCD. Since each GTG, including support systems, is located in a separate Seismic Category I structure, rupture of any piping within one GTG room will not impact the operation of the redundant GTGs.

Therefore the NRC staff finds that the EGTSS meets the requirements of GDC 4.

C. GDC 5, “Sharing of Structures, Systems, and Components”

Structures, systems and components important to safety must not be shared among nuclear units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions.

The US-APWR design can be used at either single-unit or multiple-unit sites. Nonetheless, in Table 1.9.1-1 it is stated that “DCD describes a single reference plant design.” This is also discussed in DCD Tier 2, Section 3.1.1.5. Should a multiple-unit site be proposed, the combined license applicant referencing the US-APWR design will be required to apply for the evaluation of compliance with the requirements of GDC 5, with respect to the capability of shared SSCs important to safety to perform their required safety functions. Consequently, GDC5 does not apply to the US-APWR design as described in the DCD.

D. GDC 17, "Electric Power Systems"

Provisions shall be included to minimize the probability of losing electric power required for safe shutdown, including provisions for an onsite emergency power supply that meets the required independence and redundancy criteria.

An approved industry standard for the design of gas turbines is ISO 3977 "Gas Turbine Procurement Part 3 Design Requirements," 2004. The US-APWR DCD does not reference this standard for the emergency GTGs. Therefore the staff has requested the applicant in **RAI 468-3360, Question 9.5.4-49** to add this standard as a design basis for the US-APWR GTGs and identify and justify any deviations from this standard. As an alternative, the applicant may propose some other appropriate industry standard that is specific to the type of GTGs proposed for the US-APWR and address any deviations. The resolution of this RAI will be tracked as **Open Item 9.5.4-1.** This standard is applicable to all of the emergency GTG support systems and the applicant's commitment should apply to all of the support systems.

The EGTSS is one of the support systems required for the operation of the emergency power supply GTGs. The EGTSS is designed to Quality Group C requirements. The EGTSS for each GTG is independent of the EGTSS serving the redundant GTGs. The required electrical components of each EGTSS are powered from the Class 1E power supply train that corresponds to the GTG served by that EGTSS (an ITAAC item is included to verify this design requirement).

In DCD Tier 2 Section 9.5.6.3, the applicant states that the starting system holds sufficient air to start the GTG three times without recharging between starts. The applicant states in DCD Tier 2 Table 1.9.2-9 that it conforms to SRP Section 9.5.6. However, criteria and guidance requirements in SRP Section 9.5.6 necessary to meet GDC 17 include demonstrating that the air starting system is capable of making five start attempts without recharging the receiver(s). Nevertheless, the NRC staff has accepted the GTG's three-start capability as discussed in SER Section 8.3.1.

Upon a GTG start signal, solenoid valves are energized allowing starting air to flow to the starter motors. A speed switch cuts the electrical circuit to the solenoid valves and causes the valves to close when the GTG is running on its own power. The starting system is designed to reach GTG set voltage and frequency within 100 seconds. The regulatory guidance for emergency diesel generators (EDGs) is to design such that the EDG can begin accepting load within 10 seconds of starting. The NRC staff's acceptance of the 100 second design for the GTGs is discussed in SER Section 8.3.1.

The EGTSS includes locally mounted pressure switches, pressure indicators, and overpressure protection devices. The pressure switches allow the automatic control of compressor and receiver operation. Low pressure alarms are sent to the MCR in accordance with SRP Section 9.5.6. Provisions are made to allow periodic blow down (local, manual) of the receivers as needed.

Air dryers are included to dry the starting air to a dew point of not more than 10 ºC (50 ºF) when installed in a normally controlled 21 ºC (70 ºF) environment or at least 5.5 ºC (10 ºF) less than the lowest expected ambient temperature.

It is typical for a repeated start signal to be blocked from a GTG until the system coasts down to a low speed. The US-APWR GTGs must coast down to less than 50 percent rotational speed before a re-start is permitted. The GTGs do not include a braking system, but the applicant expects the GTGs to reach this speed from a full speed trip at load within approximately 15 seconds. The NRC staff's acceptance of the intervals between start attempts is discussed in SER Section 8.3.1.

Section C.2.2.3 of "Qualification and Test Plan of Class 1E Gas Turbine Generator System," December 2007, (MUAP-07024-P(R0)) stated that the air starting system air receivers will be in accordance with ASME Section VIII. The USAPWR starting air system air receivers should be in accordance with ASME Section III, Class 3. Therefore the staff asked the applicant in RAI 319-2147, Question 9.5.6-20 to verify that the receivers are in accordance with Section III, Class 3. The applicant responded on June 9, 2009, that the air receivers are ASME III and Revision 2 of the DCD confirms this design code. However, Revision 2 of Section C.2.2.3 of "Qualification and Test Plan of Class 1E Gas Turbine Generator System," October 2010 (MUAP-07024-P(R2)), still states that the air receivers are ASME Section VIII. Consequently, this change will be tracked as **Confirmatory Item 9.5.6-1.**

According to Revision 3 of US-APWR DCD, Tier 1 Table 2.6.4-2, the starting air system piping and valves are ASME Section III, Class 3 from the discharge of the starting air compressors through to the piping connection for the air starter at the GTG skid. According to US-APWR DCD Tier 2 Figure 9.5.6-1, the starting air system is nonsafety-related up to the inlet of the check valve at the inlet of each starting air receiver. Therefore the staff requested the applicant in **RAI 754-5617, Question 14.3.6-28** to address this inconsistency and revise the DCD accordingly. The applicant responded on July 15, 2011, stating that the ASME Section III boundaries are as shown on Figure 9.5.6-1. The applicant proposed revising Tier 1, Table 2.6.4-2 to be consistent with this figure. The staff finds the RAI response to be acceptable and considers RAI 754-5617, Question 14.3.6-28 to be closed. The inclusion of the proposed changes described in the response to RAI Question 14.3.6-28 is being tracked as **Confirmatory Item 9.5.6-2**.

Section C.2.2.11.4 of "Qualification and Test Plan of Class 1E Gas Turbine Generator System," December 2007, (MUAP-07024-P(R0)) indicates that pipes from air tanks to the generator set shall be zinc coated to prevent pipes from rusting. DCD Tier 2 Table 9.5.6-1 indicates that piping will be stainless steel and carbon steel. Therefore the staff asked the applicant in RAI 319-2147, Question 9.5.6-22 to provide more specific information on which piping is carbon steel, which is stainless steel and which is zinc coated. The applicant responded on June 9, 2009, that zinc coated piping would not be used for the EGTSS and this RAI response is acceptable. However, Revision 2 of Section C.2.2.11.4 of "Qualification and Test Plan of Class 1E Gas Turbine Generator System," October 2010 (MUAP-07024-P(R2)), still states that pipes from air tanks to the generator set shall be zinc coated to prevent pipes from rusting. Consequently, this change will be tracked as **Confirmatory Item 9.5.6-3.**

Therefore the NRC staff finds that the EGTSS meets the requirements of GDC 17.

ITAAC: ITAAC items specific to the emergency power sources are listed in DCD Tier 1 Table 2.6.4-1. The items related to the EGTSS are as follows:

- Item 1 requires an inspection to verify that the as-built GTG system is functionally consistent with the description in DCD Section 2.6.4.1.

- Item 3 requires an inspection to ensure that each independent GTG has its own dedicated fuel oil supply and transfer, lubrication, starting, and combustion air intake and exhaust systems.

- Item 4 requires an inspection and test to verify that each emergency GTG support system is provided power by the same division of the Class 1E power system as the respective emergency GTG.

- Item 7 requires hydrostatic tests be performed on the as-built components and piping of the EPS support systems as required by ASME Section III. This includes verification that ASME Code Data Reports have been completed and are in the plant records.

- Item 8 requires inspections and type tests, analyses or a combination of type tests and analyses to verify that the Seismic Category I EPS support system equipment and piping, including supports, can withstand seismic design basis loads without loss of safety function.

- Item 10 requires a test of the as-built starting air system to verify that the system is capable of providing 3 starts of the as-built EGTGs without replenishing the air receivers.

- Item 12 requires an inspection and test to ensure that each GTG system is independent of the other GTG systems and each of the four GTGs is located in a separate room of the PS/B. Revision 3 of Tier 1 of the US-APWR DCD replaced the statement that "Each Class 1E EPS is located in a separate room in the PS/B" with the statement that "The Class 1E EPSs are located in separate rooms in the PS/B." This new statement in 12.b should similarly make it clear that each Class 1E EPS train is located in a separate room of the PS/B. This comment also applies to the description in Tier 1, Table 2.6.4-1, Item 12.b. Therefore the staff requested the applicant in **RAI 754-5617, Question 14.3.6-20** to revise the wording of this ITAAC to clarify the design. The applicant responded on July 15, 2011, that Tier 1, Table 2.6.4-1, ITAAC Item 12.b, Design Commitment, will be revised to state that "Each redundant division of Class 1E EPSs is located in a separate room of the PS/B." The corresponding ITAAC Acceptance Criteria and Section 2.6.4.1 will be similarly revised. The staff finds the RAI response to be acceptable and considers RAI 754-5617, Question 14.3.6-20 to be closed. The inclusion of the proposed changes described in the response to RAI Question 14.3.6-20 is being tracked as **Confirmatory Item 9.5.4-1**.

- Item 13 requires a test to verify that the EGTGs can start and ramp up to the set voltage and frequency within 100 seconds of receiving a start signal.

- Item 14.a requires a test to verify that the EGTGs are started by the ECCS actuation signal.

- Item 15.a requires a test to demonstrate that the GTG system starts upon a loss of power to a Class 1E bus.

- Item 17 requires a test to demonstrate that the as-built Class 1E GTGs are capable of responding to an automatic start signal when running for test purposes.

- Item 19 addresses the functional arrangements of the fuel oil storage and transfer system and the ventilation/cooling air intake and exhaust system. There is no similar item in Section 2.6.4.1 for the lube oil and starting air systems. Since all of these systems are required to support the safety function of the EPS, they should be treated similarly in this section. Therefore the staff requested the applicant in **RAI 754-5617, Question 14.3.6-24** to revise the ITAAC accordingly. The applicant responded on July 15, 2011, stating that DCD Tier 1 Section 2.6.4.2, Design Description 19 and Table 2.6.4-1, ITAAC No. 19 will be revised to include the EGTSS. The staff finds the RAI response to be acceptable and considers RAI 754-5617, Question 14.3.6-24 to be closed. The inclusion of the proposed changes described in the response to RAI Question 14.3.6-24 is being tracked as **Confirmatory Item 9.5.6-4**.

- Item 23 requires inspections to be performed to verify retrievability of the alarms provided in the MCR as described in DCD Section 2.6.4.2 for the as-built EGTG support systems.

- Item 26 requires inspections and reconciliation analyses to verify that the ASME Section III components and piping (including piping supports) of the as-built emergency GTG support systems are designed, fabricated, installed and inspected in accordance with ASME Section III requirements and that all required ASME documentation is provided.

- Item 27 requires non-destructive examination of the as-built pressure boundary welds for ASME Section III components and piping and verification that all required ASME documentation is provided.

The staff concludes that the EGTSS ITAAC for the US-APWR are acceptable and in accordance with 10 CFR 52.47(b)(1).

TS and Initial Plant Test Program: The TS are presented in Chapter 16 of the DCD Tier 2 document. SR 3.8.3.4 requires a test of the pressure stored in the receiver monthly. Since there is a low pressure alarm associated with each receiver, this test frequency is deemed sufficient. The staff finds the US-APWR TS requirements for the EGTSS to be consistent with the applicable NRC standard TS, and therefore, is considered acceptable.

RG 1.9 specifies that a slow-start test should be performed every month and a fast-start test should be performed every six months. This schedule is designed to reduce the wear and stress caused by a fast-start while still ensuring system performance. Section 16 of the US-APWR DCD Tier 2 requires the same test monthly via SR 3.8.1.2 to demonstrate the EGTGs fast-start capability. The applicant does not differentiate between fast and slow starts. In the report “Justification for deviations between NUREG-1431 Rev. 3.1 and US-APWR Technical Specifications,” dated August 2008, the applicant states that the GTG system does not require a slow start. This is because, unlike diesels, the starting time of a gas turbine has little influence on machine stress and wear.

SR 3.8.3.4 requires verifying every 31 days that the pressure of each GTG air receiver is 18.6 bar (270 psig) or higher.

Initial testing of the GTG system is described in DCD Tier 2 Section 14.2.12.1.44. Most tests of the GTG system will test the EGTSS since most tests begin with the GTG at rest. Inspection of piping is performed in accordance with the requirements of ASME Section XI, as discussed in DCD Tier 2 Section 6.6. The tests described in the DCD for the EGTSS are acceptable to the staff.

9.5.6.5 Combined License Information Items

There are no COL information items pertaining to the EGTSS provided in DCD Tier 2, Section 9.5.6. This is found to be acceptable to the NRC staff if the above RAI item and Confirmatory Items are satisfied within the DCD and documents referenced by the DCD.

9.5.6.6 Conclusions

The NRC staff concludes that, pending resolution of **RAI 468-3360, Question 9.5.4-49, Open Item 9.5.4-1** and satisfactory closure of **Confirmatory Items 9.5.4-1, 9.5.6-1, 9.5.6-2, 9.5.6-3, and 9.5.6-4**, the emergency GTG starting system design is acceptable and complies with regulations as stated in the general design criteria of Appendix A to 10 CFR Part 50, as well as 10 CFR 52.47(b)(1). Pending resolution of the RAIs, this conclusion is based on the technical evaluation that determined the DCD meets GDC 2, GDC 4, GDC 5, GDC 17, and 10 CFR 52.47(b)(1).

9.5.7 Gas Turbine Lubrication System (Related to RG 1.206, Section C.III.1, Chapter 9, C.I.9.5.7, "Diesel Generator Lubrication System")

9.5.7.1 Introduction

The review of the Class 1E emergency GTG lubrication system (EGTLS) provides essential lubrication to GTG components. Review of the GTG lubrication system is to assure compliance with the requirements of GDCs 2, 4, 5, and 17.

The US-APWR reactor design provides GTGs in lieu of diesel generators to perform the standby emergency power supply function required by GDC 17, "Electric Power Systems." The Standard Review Plan (NUREG-0800) does not include guidance for standby GTG support systems. However, the guidance in SRP Section 9.5.7 is used to the extent applicable for the review and safety evaluation report preparation for this section of the US-APWR DCD. In addition, the staff considered the information in Interim Staff Guidance Document ISG-021, "Interim Staff Guidance on the Review of Nuclear Power Plant Designs using a Gas Turbine Driven Standby Emergency Alternating Current Power System" (ISG-021), to inform the staff's review and safety evaluation report. The applicant states in DCD Tier 2 Table 1.9.2-9 that the US-APWR design conforms to SRP Section 9.5.7 with no exception.

Each of the four redundant Class 1E emergency power supplies, referred to as a GTG, is a skid-mounted, enclosed package consisting of two gas turbines operating in parallel to drive a single generator through a gearbox. The lubrication system is integral to the on-skid package with no piping or components external to the skid.

9.5.7.2 Summary of Application

DCD Tier 1: The Tier 1 information associated with this section is found in Tier 1, Section 2.6.4 and Table 2.6.4-1.

DCD Tier 2: The applicant has provided a Tier 2 description in Section 9.5.7, summarized here in part as follows:

> The US-APWR's EGTLS provides lubricating oil to all gas turbine bearings during GTG operation and shutdown. The GTG lubrication system provides lubrication to each of the four Class 1E emergency GTGs, to safely shut down the plant and maintain a safe shutdown condition following a DBA concurrent with a LOOP. The applicant states that the GTG lubrication system is designed so that a single failure of any active component, assuming a loss of offsite power, cannot result in complete loss of the power source function.
>
> The system for each GTG includes two gas turbine shaft driven pumps, a reduction gear box (including its oil reservoir), a suction strainer for each oil pump, a full-flow filter for each pump, a lube oil cooler for each pump, oil cooler fan, and associated valves, piping, and instrumentation. The system circulates oil through the lube oil strainer, lube oil cooler, lube oil filter, and through the gas turbine bearings.
>
> A description of the system, the design basis, and design parameters are presented in the US-APWR DCD, including a simplified system diagram.

ITAAC: The ITAAC associated with Tier 2, Section 9.5.7 are given in Tier 1, Section 2.6.4 and Table 2.6.4-1.

TS: The TS associated with DCD Tier 2, Section 9.5.7 are given in DCD Tier 2, Chapter 16, Section 3.8.3 "Class 1E Gas Turbine Generator Fuel Oil, Lube Oil, and Starting Air."

The EGTLS is tested prior to initial startup. Preoperational testing is described in DCD Tier 2 Section 14.2.12.1.44. Each test of system operation will test the EGTLS operation. System performance is verified during periodic GTG testing.

9.5.7.3 Regulatory Basis

The relevant requirements of the Commission regulations for this area of review, and the associated acceptance criteria, are given in Section 9.5.7 of NUREG-0800 and are summarized below. Further guidance and review interfaces with other SRP sections also can be found in Section 9.5.7.I of NUREG-0800.

1. GDC 2, "Design Bases for Protection Against Natural Phenomena," as it relates to SSCs that must be protected from, or be capable of withstanding, the effects of natural phenomena like earthquakes, tornadoes, hurricanes, and floods as established in DCD Chapters 2 and 3.

2. GDC 4, "Environmental and Dynamic Effects Design Bases," as it relates to SSCs that must be protected from, or be capable of withstanding the effects of, externally- and internally-generated missiles, pipe whip, and jet impingement forces associated with pipe breaks.

3. GDC 5, "Sharing of Structures, Systems, and Components," as it relates to the capability of systems and components important to safety shared between units to perform required safety functions.

4. GDC 17 "Electric Power Systems," as it relates to capability to meet independence and redundancy criteria.

5. 10 CFR 52.47(b)(1), which requires that a DC 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 DC is built and will operate in accordance with the DC, the provisions of the Atomic Energy Act, and the NRC's regulations.

Acceptance criteria adequate to meet the above requirements include:

> The GTG lubricating system design may conform to applicable portions of ANSI/ANS-59.52-1988, "Lubricating Oil Systems for Safety-Related Diesel Generators," regarding complete independence of other GTGs such that a single failure will not cause loss of required minimum GTG capacity for the site. Also, the onsite capacity for each GTG must be sufficient for seven days operation after any design basis event and continuing LOOP.

9.5.7.4 Technical Evaluation

The staff has reviewed the EGTLS as presented in the DCD submitted in March 2011 (Revision 3). This review also considered the relevant portions of the "Qualification and Test Plan of Class 1E Gas Turbine Generator System," October 2010 (MUAP-07024-P (R2)), which was submitted by MHI, and is referenced in Section 8.3.1 of the DCD. The staff directed its evaluation to determine whether the EGTLS design complies with the requirements of GDC 2, 4, 5, and 17 and 10 CFR 52.47(b)(1). The EGTLS provides lubrication oil to Class 1E GTGs which are required to safely shut down the plant and maintain a safe shutdown condition following a DBA concurrent with a LOOP by supplying power to essential loads.

Section 9.5.7.2 of Tier 2 of the US-APWR DCD provides a system description of the EGTLS. Staff acceptance of the US-APWR EGTLS is based on meeting the regulatory basis for this system as follows:

A. GDC 2, "Design Bases for Protection Against Natural Phenomena"

GDC 2 requires that the EGTLS be protected from, or be capable of withstanding the effects of natural phenomena. Portions of the system important to safety are housed within Seismic Category I structures.

The EGTLS is an integral subsystem of the GTG package and is thus located within the GTG unit enclosure. However, the lube oil cooling function of the system relies on the building cooling function which is provided by the GTG air intake and exhaust subsystem evaluated in SER Section 9.5.8. The portions of the building cooling system that are located on the roof are protected in accordance with GDC 2. Each GTG room contains a single GTG. The GTG rooms are separated by fire-rated barriers such that a fire in one GTG room will not impact more than one GTG.

The EGTLS is designed in accordance with Seismic Category I requirements as specified in Section 3.2 of the DCD. System, equipment, and components which are not normally required to be Seismic Category I based on their safety function, but whose failure could impair the functioning of the lubrication system are upgraded in design to Seismic Category I.

Therefore the NRC staff finds that the EGTLS meets the requirements of GDC 2.

B. GDC 4, "Environmental and Dynamic Effects Design Bases"

GDC 4 requires that the EGTLS must be protected from, or be capable of withstanding the effects of, externally- and internally-generated missiles, pipe whip, and jet impingement forces associated with pipe breaks. The portions of the building cooling system that are located on the roof are protected in accordance with GDC 4 as discussed in SER Section 9.5.8.

DCD Tier 2 Section 3.5 states that the GTGs are considered potential sources of missile generation. However, missiles generated within the GT are not postulated by the applicant because of an over-speed prevention system and the casing that prevents penetration. The power section of the gas turbine is designed so that the capacity of the casing to absorb energy is greater than the kinetic energy of rotational parts of the turbine. Missiles are not postulated to be generated by the GTG.

The dynamic effects associated with postulated rupture of piping are addressed in Chapter 3 of the DCD. Since each GTG, including its support systems, is located in a separate Seismic Category I structure, rupture of any piping within one GTG room will not impact the operation of the redundant GTGs.

Therefore the NRC staff finds that the EGTLS meets the requirements of GDC 4.

C. GDC 5, "Sharing of Structures, Systems, and Components"

GDC 5 requires that SSCs important to safety must not be shared among nuclear units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions.

The US-APWR design can be used at either single-unit or multiple-unit sites. Nonetheless, in Table 1.9.1-1 it is stated that "DCD describes a single reference plant design." This is also discussed in DCD Tier 2, Section 3.1.1.5. Should a multiple-unit site be proposed, the combined license applicant referencing the US-APWR design will be required to apply for the evaluation of compliance with the requirements of GDC 5, with respect to the capability of shared SSCs important to safety to perform their required safety functions. Consequently, GDC 5 does not apply to the US-APWR design as described in the DCD.

D. GDC 17, "Electric Power Systems"

Provisions shall be included to minimize the probability of losing electric power required for safe shutdown, including provisions for an onsite emergency power supply that meets the required independence and redundancy criteria. The EGTLS must have the capability to meet independence and redundancy criteria.

An approved industry standard for the design of gas turbines is ISO 3977 “Gas Turbine Procurement Part 3 Design Requirements,” 2004. The US-APWR DCD does not reference this standard for the emergency GTGs. Therefore the staff has requested the applicant in **RAI 468-3360, Question 9.5.4-49** to add this standard as a design basis for the US-APWR GTGs and identify and justify any deviations from this standard. As an alternative, the applicant may propose some other appropriate industry standard that is specific to the type of GTGs proposed for the US-APWR and address any deviations. The resolution of this RAI will be tracked as **Open Item 9.5.4-1.** This standard is applicable to all of the emergency GTG support systems and the applicant’s commitment should apply to all of the support systems.

The EGTLS is one of the support systems required for the operation of the emergency power supply GTGs. The EGTLS is designed to Quality Group C requirements. The EGTLS for each GTG is independent of the EGTLS serving the redundant GTGs. The required electrical components of each EGTLS are powered from the Class 1E power supply train that corresponds to the GTG served by that EGTLS (an ITAAC item is included to verify this design requirement).

When the GTG is operating, lubricating oil circulation is accomplished by the gas turbine shaft driven pumps, which draw oil from the reduction gear oil reservoir through a suction strainer, and pass it through a full-flow, duplex filter and air-cooled lube oil cooler before distribution to the bearings. A schematic drawing of the EGTLS is provided in Figure 9.5.7-1 of the DCD. The EGTLS is housed entirely within the GTG enclosure in the gas turbine engine-gearbox package. According to the DCD, all system components are proven of equivalent quality to ASME Section III, Class 3. This is interpreted by the applicant to mean that an item designed for commercial use is upgraded to ASME Section III, Class 3 requirements through seismic design, testing, qualification and documentation.

The US-APWR GTGs do not require a prelubrication system because the GTG bearings are ball type. In addition, a lube oil keep-warm function is not required for the GTGs based on the use of aviation type lubrication oil which has a low pour point.

The lube oil will be tested for kinematic viscosity, water content, wear metal content, and all acid value. These tests will be performed and accepted in accordance with the manufacturer’s recommendations.

During operation of the gas turbine, failure of the gas turbine shaft driven pumps and/or spurious opening of the pressure regulating valves results in unsatisfactorily low lube oil pressure. During routine operation receipt of a low lube oil pressure signal from the trip logic will shut down the respective GTG. Loss of cooling to the lube oil cooler and/or failure of the temperature regulating valve to open would cause a high lube oil temperature condition and alarm. During routine operation receipt of a high lube oil temperature signal from the trip logic will shut down the respective GTG. However, all of these trip signals are bypassed or defeated when the Class 1E Emergency Power Sources (EPS) are started by an ECCS) actuation signal as required by RG 1.9. An ITAAC is included to verify this function.

Therefore the NRC staff finds that the EGTLS meets the requirements of GDC 17.

ITAAC: ITAAC items specific to the emergency power sources are listed in DCD Tier 1 Table 2.6.4-1. The items related to the EGTLS are as follows:

- Item 1 requires an inspection to verify that the as-built GTG system is functionally consistent with the description in DCD Section 2.6.4.1.

- Item 3 requires an inspection to ensure that each independent GTG has its own dedicated fuel oil supply and transfer, lubrication, starting, and combustion air intake and exhaust systems.

- Item 4 requires an inspection and test to verify that each emergency GTG support system is provided power by the same division of the Class 1E power system as the respective emergency GTG.

- Item 8 requires inspections and type tests, analyses or a combination of type tests and analyses to verify that the Seismic Category I EPS support system equipment and piping, including supports, can withstand seismic design basis loads without loss of safety function.

- Item 12 requires an inspection to ensure that each GTG system is independent of the other GTG systems and each of the four GTGs is located in a separate room of the PS/B. Rev 3 of Tier 1 of the US-APWR DCD replaced the statement that "Each Class 1E EPS is located in a separate room in the PS/B" with the statement that "The Class 1E EPSs are located in separate rooms in the PS/B." This new statement in 12.b should similarly make it clear that <u>each</u> Class 1E EPS train is located in a separate room of the PS/B. This comment also applies to the description in Tier 1, Table 2.6.4-1, Item 12.b. Therefore the staff requested the applicant in **RAI 754-5617, Question 14.3.6-20** to revise the wording of this ITAAC to clarify the design. The applicant responded on July 15, 2011, that Tier 1, Table 2.6.4-1, ITAAC Item 12.b, Design Commitment, will be revised to state that "Each redundant division of Class 1E EPSs is located in a separate room of the PS/B." The corresponding ITAAC Acceptance Criteria and Section 2.6.4.1 will be similarly revised. The staff finds the RAI response to be acceptable and considers RAI 754-5617, Question 14.3.6-20 to be closed. The inclusion of the proposed changes described in the response to RAI Question 14.3.6-20 is being tracked as **Confirmatory Item 9.5.4-1**.

- Item 16 requires a test to verify that all the as-built Class 1E EPS protection systems, except for severe failure protection, are bypassed when the Class 1E EPS is started by an ECCS actuation signal. The Acceptance Criteria for this ITAAC should require that the as-built protection systems are <u>automatically</u> bypassed when the Class 1E EPS is started by an ECCS actuation signal. Therefore the staff requested the applicant in **RAI 754-5617, Question 14.3.6-23** to include the requirement for automatic bypass. The applicant responded on July 15, 2011, stating that DCD Section 2.6.4.1, Design Description 16 and Table 2.6.4-1, ITAAC No. 16 will be revised to specify an automatic bypass. The staff finds the RAI response to be acceptable and considers RAI 754-5617, Question 14.3.6-23 to be closed. The inclusion of the proposed changes described in the response to RAI Question 14.3.6-23 is being tracked as **Confirmatory Item 9.5.7-1**.

- Item 19 addresses the functional arrangements of the fuel oil storage and transfer system and the ventilation/cooling air intake and exhaust system. There is no similar item in Section 2.6.4.1 for the lube oil and starting air systems. Since all of these systems are required to support the safety function of the EPS, they should be treated similarly in this section. Therefore the staff requested the applicant in **RAI 754-5617, Question 14.3.6-24** to revise the ITAAC accordingly. The applicant responded on July 15, 2011, stating that DCD Tier 1 Section 2.6.4.2, Design Description 19 and Table 2.6.4-1, ITAAC No. 19 will be revised to include the EGTLS. The staff finds the RAI response to be acceptable and considers RAI 754-5617, Question 14.3.6-24 to be closed. The inclusion of the proposed changes described in the response to RAI Question 14.3.6-24 is being tracked as **Confirmatory Item 9.5.6-4**.

- Item 23 requires a test of the EGTLS status alarms. The test verifies that the alarms are received in the MCR as described in the DCD.

- Item 30 requires analyses and inspection to determine the required lubricating oil tank volume to provide a seven day supply of lubricating oil to its respective Class 1E EPS and that the as-built tank volume bounds the analysis. The oil consumption will likely increase as the GT ages. Therefore the staff requested the applicant in **RAI 754-5617, Question 14.3.6-26** to revise this ITAAC to require that the oil capacity verified is based on the maximum expected oil consumption rate, e.g., just prior to a scheduled overhaul. The applicant responded on July 15, 2011, stating that DCD Tier 1 Section 2.6.4.3, Design Description 30 and Table 2.6.4-1, ITAAC No. 30 will be revised to specify that the lubricating oil consumption rate for calculation of the lubricating oil tank capacity will be the maximum expected oil consumption rate immediately prior to scheduled overhaul. The staff finds the RAI response to be acceptable and considers RAI 754-5617, Question 14.3.6-26 to be closed. The inclusion of the proposed changes described in the response to RAI 754-5617, Question 14.3.6-26 is being tracked as **Confirmatory Item 9.5.7-2**.

- Item 31 requires an inspection of each of the GT main shaft driven lubricating oil pumps to verify that the pumps are designed to circulate lubrication oil to the engine during operation.

TS and Initial Plant Test Program: SR 3.8.3.2 in Chapter 16 of the DCD states that a minimum of 306.6 liters (81 gallons) of lube oil inventory must be maintained for each EGTLS. The Bases Background for the SR (B 3.8.3) states that the engine oil sump in each Class 1E GTG gear box contains an inventory capable of supporting a minimum of 7 days of operation. The lube oil capacity is based on the lube oil consumption for continuous operation at the DG rated load including consideration for increased lube oil consumption during the design life with appropriate maintenance. The design lube oil consumption for each GTG is 0.02 liters/hr (0.053 gal/hr). The staff finds the US-APWR TS requirements for the EGTLS to be consistent with applicable NRC standard TS and is considered acceptable.

US-APWR DCD Section 14.12.1.44 includes preoperational tests to verify the operation of the EGTLS. Each test of system operation will test the EGTLS operation. System performance is verified during periodic GTG testing. The tests described in the DCD for the EGTLS are acceptable to the staff.

9.5.7.5 Combined License Information Items

There are no COL information items pertaining to the EGTLS provided in DCD Tier 2, Section 9.5.7. This is found to be acceptable if the above RAI items and confirmatory items are satisfied within the DCD.

9.5.7.6 Conclusions

The NRC staff concludes that, with the exception of satisfactory closure of **RAI 468-3360, Question 9.5.4-49, Open Item 9.5.4-1**, and closure of Confirmatory Items 9.5.4-1, 9.5.6-4, 9.5.7-1, and 9.5.7-2, the GTG lubrication system design is acceptable and complies with regulations as stated in the general design criteria of Appendix A to 10 CFR Part 50. Pending resolution of the RAIs, this conclusion is based on the technical evaluation that determined the DCD meets GDC 2, GDC 4, GDC 5, GDC 17, and 10 CFR 52.47(b)(1).

9.5.8 Gas Turbine Generator Combustion Air Intake and Exhaust System (Related to RG 1.206, Section C.III.1, Chapter 9, C.I.9.5.8, "Diesel Generator Combustion Air Intake and Exhaust System")

9.5.8.1 Introduction

The review of the Class 1E emergency GTG combustion air intake and exhaust system (EGTCAIES) is to assure compliance with the requirements of GDCs 2, 4, 5, and 17. The system is reviewed from the outside air intake to the combustion air supply lines connected to the GTG interface and from the exhaust connections at the GTG interface to the discharge point outside the building.

The US-APWR reactor design provides GTGs in lieu of diesel engine generators to perform the standby emergency power supply function required by GDC 17, Electric Power Systems. The Standard Review Plan (NUREG-0800) does not include guidance for emergency GTG support systems. However, the guidance in SRP Section 9.5.8 is used to the extent applicable for the review and safety evaluation report preparation for this section of the US-APWR DCD. In addition, the staff considered the information in Interim Staff Guidance Document ISG-021, "Interim Staff Guidance on the Review of Nuclear Power Plant Designs using a Gas Turbine Driven Standby Emergency Alternating Current Power System" (ISG-021), to inform the staff's review and safety evaluation report. The applicant states in DCD Tier 2 Table 1.9.2-9 that the US-APWR design conforms to SRP Section 9.5.8 with no exception.

Each of the four redundant Class 1E emergency power supplies, referred to as a GTG, is a skid-mounted, enclosed package consisting of two gas turbines operating in parallel to drive a single generator through a gearbox.

9.5.8.2 Summary of Application

DCD Tier 1: The Tier 1 information associated with this section is found in Tier 1, Section 2.6.4 and Table 2.6.4-1.

DCD Tier 2: The applicant has provided a Tier 2 description in Section 9.5.8, summarized here in part as follows:

The US-APWR's EGTCAIES supplies combustion air and exhausts combustion products for each of the four Class 1E emergency GTGs, to safely shut down the plant and maintain a safe shutdown condition following a DBA concurrent with a LOOP. The EGTCAIES also provides ventilation/cooling air for each GTG assembly.

The applicant states that the EGTCAIES is capable of supplying adequate combustion air and disposing of resultant exhaust products to permit continuous operation of the GTGs when operating at 110 percent of nameplate rating. The combustion air intake and exhaust system is designed so that a single failure of any component, assuming a loss of offsite power, cannot result in complete loss of the emergency power source.

Each gas turbine is provided with a combustion air intake and exhaust system consisting of air intake weather louver with screen, exhaust silencer, and associated piping and flexible connections, as well as ventilation/cooling air to the GTG assembly consisting of ventilation fans and duct work. A description of the system, the design basis, and design features are presented in the US-APWR DCD, including a simplified system diagram as well as inspection and testing requirements for the system.

ITAAC: The inspections, tests, analyses, and acceptance criteria (ITAAC) associated with Tier 2, Section 9.5.8 are given in Tier 1, Section 2.6.4 and Table 2.6.4-1.

TS: SR 3.8.1.12 requires verification that each Class 1E GTG's noncritical automatic trips are bypassed on actual or simulated loss of voltage signal on the emergency bus concurrent with an actual or simulated ESF actuation signal. This includes high GT exhaust gas temperature. Otherwise, the TS of DCD Tier 2, Chapter 16 do not specifically identify the GTG air intake and exhaust systems. However, GTG testing and SRs under TS 3.8.1 will measure the effectiveness of air intake and exhaust because these systems are an integral part of GTG performance and capacity.

9.5.8.3 Regulatory Basis

The relevant requirements of the Commission regulations for this area of review, and the associated acceptance criteria, are given in Section 9.5.8 of NUREG-0800 and are summarized below. Further guidance and review interfaces with other SRP sections also can be found in Section 9.5.8.I of NUREG-0800.

1. GDC 2, “Design Bases for Protection Against Natural Phenomena,” as it relates to SSCs that must be protected from, or be capable of withstanding, the effects of natural phenomena like earthquakes, tornadoes, hurricanes, and floods as established in DCD Chapters 2 and 3.

2. GDC 4, “Environmental and Dynamic Effects Design Bases,” as it relates to SSCs that must be protected from, or be capable of withstanding the effects of, externally- and internally-generated missiles, pipe whip, and jet impingement forces associated with pipe breaks.

3. GDC 5, “Sharing, of Structures, Systems, and Components,” as it relates to the capability of systems and components important to safety shared between units to perform required safety functions.

4. GDC 17, “Electric Power Systems”, as it relates to capability to meet independence and redundancy criteria.

5. 10 CFR 52.47(b)(1), which requires that a DC 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 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.

Acceptance criteria adequate to meet the above requirements include:

1. The guidelines of NUREG/CR-0660, Enhancement of Onsite Emergency Diesel Generator (EDG) Reliability, may be used to satisfy GDC 17. Combustion air should be from outside the building with the air intake sufficiently (20 feet) above ground and filtered to prevent degradation. Piping for room ventilation should be separate from intake piping. Exhaust gases should not circulate back into the GTG room, fuel storage room, or any part of the power plant.

2. Each GTG should have a dedicated air intake and exhaust system that is physically arranged to prevent unacceptable degradation of performance when the generator operates continuously at peak output. The combustion air intake system must provide any filtration and/or conditioning of combustion air required to ensure design basis GTG performance (output and duration) for the full range of expected ambient conditions at the plant site, including airborne particulate levels.

9.5.8.4 Technical Evaluation

The staff has reviewed the EGTCAIES as presented in the DCD submitted in March 2011 (Revision 3). This review also considered the relevant portions of the “Qualification and Test Plan of Class 1E Gas Turbine Generator System,” October 2010 (MUAP-07024-P(R2)), which was submitted by MHI, and is referenced in the DCD in Section 8.3.1. The staff directed its evaluation to determine whether the EGTCAIES design complies with the requirements of GDC 2, 4, 5, 17 and 10 CFR 52.47(b)(1). The EGTCAIES supports the operation of the Class 1E GTGs which are required to safely shut down the plant and maintain a safe shutdown condition following a DBA concurrent with a LOOP by supplying power to essential loads. Each independent EGTCAIES supplies intake air to one of the four emergency power supply GTGs and exhausts combustion products from the gas turbine to the atmosphere. The air intake also provides ventilation/cooling air for the associated GTG and enclosure building.

Section 9.5.8.2 of Tier 2 of the US-APWR DCD provides a system description of the EGTCAIES. Staff acceptance of the US-APWR EGTCAIES is based on meeting the regulatory basis for this system as follows:

A. GDC 2, “Design Bases for Protection Against Natural Phenomena”

GDC 2 requires that the EGTCAIES be protected from, or be capable of withstanding the effects of natural phenomena. Portions of the system are housed within Seismic Category I structures that also provide protection from tornadoes, hurricanes, and floods. The remaining portions of the EGTCAIES are located on the roof of the building housing the GTGs and are protected by

Seismic Category I guard structures. These guard structures also protect against precipitation and tornado missiles. The design details that protect the combustion air inlet from ingestion of snow and/or rain are not adequately described in the DCD. Therefore, the staff has requested the applicant in **RAI 704-5248, Question 9.5.8-28** to describe in detail how the combustion air intake will be designed to prevent the ingestion of snow and rain. The applicant responded on July 4, 2011, with proposed changes to the physical drawings depicting the GTG combustion air intake and ventilation air intake. The revised drawings demonstrate how the inlet configuration will protect the operation of the GTGs from the effects of snow and rain. The staff finds the RAI response to be acceptable and considers RAI 5258, Question 9.5.8-28 to be closed. The inclusion of the proposed changes described in the response to RAI Question 9.5.8-28 is being tracked as **Confirmatory Item 9.5.8-1.**

The reinforced guard structures are integrally attached to the building roof and act as extensions of the Seismic Category I buildings. The guard structures are designed as Seismic Category I to withstand the effects of natural phenomena in accordance with GDC 2.

The EGTCAIES is designed in accordance with Seismic Category I requirements as specified in US-APWR DCD Section 3.2. According to the US-APWR DCD, when Seismic Category I components are not available, and failure of those components could impair the functioning of the system, the components used are proven to be of equivalent quality through design and/or testing. Systems, equipment and components which are not Seismic Category I and whose failure could impair the functioning of the EGTCAIES are upgraded to Seismic Category I. Each GTG room contains a single GTG. The GTG rooms are separated by fire-rated barriers such that a fire in one GTG room will not impact more than one GTG.

Therefore the NRC staff finds that the EGTCAIES meets the requirements of GDC 2.

B. GDC 4, "Environmental and Dynamic Effects Design Bases"

GDC 4 requires that the EGTCAIES must be protected from, or be capable of withstanding the effects of, externally- and internally-generated missiles, pipe whip, and jet impingement forces associated with pipe breaks.

DCD Tier 2 Section 3.5 states that the GTGs are considered potential sources of missile generation. However, missiles generated within the GT are not postulated by the applicant because of an over-speed prevention system and the casing that prevents penetration. The power section of the gas turbine is designed so that the capacity of the casing to absorb energy is greater than the kinetic energy of rotational parts of the turbine. Missiles are not postulated to be generated by the GTG.

The dynamic effects associated with postulated rupture of piping are addressed in Chapter 3 of the DCD. Since each GTG, including its support systems, is located in a separate Seismic Category I structure, rupture of any piping within one GTG room will not impact the operation of the redundant GTGs.

Therefore the NRC staff finds that the EGTCAIES meets the requirements of GDC 4.

C. GDC 5, "Sharing of Structures, Systems, and Components"

GDC 5 requires that structures, systems and components important to safety must not be shared among nuclear units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions.

The USAPWR design can be used at either single-unit or multiple-unit sites. Nonetheless, in Table 1.9.1-1 it is stated that “DCD describes a single reference plant design.” This is also discussed in DCD Tier 2, Section 3.1.1.5. Should a multiple-unit site be proposed, the combined license applicant referencing the US-APWR design will be required to apply for the evaluation of compliance with the requirements of GDC 5, with respect to the capability of shared SSCs important to safety to perform their required safety functions. Consequently, GDC 5 does not apply to the US-APWR design as described in the DCD.

D. GDC 17, “Electric Power Systems”

Provisions shall be included to minimize the probability of losing electric power required for safe shutdown, including provisions for an onsite emergency power supply that meets the required independence and redundancy criteria. The EGTCAIES must have the capability to meet independence and redundancy criteria.

Each GTG is served by an independent EGTCAIES with no interconnections to the EGTCAIES’s that serve the redundant GTGs. The required redundancy is provided by each GTG and its support systems. DCD Tier 2 Section 9.5.8.3.C states that a single failure is assessed as a failure of the GTG with which the component is associated. In such a circumstance, safe shutdown is attained and maintained by the redundant GTG installation.

An approved industry standard for the design of gas turbines is ISO 3977 “Gas Turbine Procurement Part 3 Design Requirements,” 2004. The US-APWR DCD does not reference this standard for the emergency GTGs. Therefore the staff has requested the applicant in **RAI 468-3360, Question 9.5.4-49** to add this standard as a design basis for the US-APWR GTGs and identify and justify any deviations from this standard. As an alternative, the applicant may propose some other appropriate industry standard that is specific to the type of GTGs proposed for the US-APWR and address any deviations. The resolution of this RAI will be tracked as **Open Item 9.5.4-1.** This standard is applicable to all of the emergency GTG support systems and the applicant’s commitment should apply to all of the support systems.

Combustion air enters the gas turbine directly from outside the PS/B through the intake air duct located on the roof. The roof of the building is ~ 12 meters (40 feet) above grade which satisfies the SRP 9.5.8 acceptance criteria that the intake be at least 6 meters (20 feet) above grade. The combustion air intake and exhaust piping is separate from the GTG ventilation/cooling system intake and exhaust ducts.

Upon initiation of a GTG start signal, combustion air is drawn into the intake opening on the roof of the PS/B and passes through the intake piping to the GT intake manifolds. The combustion air intake piping is sized to supply an adequate supply of air to the GT while operating up to 110 percent of nameplate rating. The turbine exhaust gases enter the turbine exhaust pipe, pass through the turbine exhaust silencer, and are then ducted out of the building. The exhaust piping and silencer are sized to prevent excessive backpressure on the engine when operating up to 110 percent nameplate rating.

The GTG ventilation/cooling function components are in accordance with the applicable codes and standards for plant safety-related HVAC components as listed in Table 3.2-2 for HVAC systems in general. The EGTCAIES piping and ductwork are Quality Group C.

A variable damper is installed in the cooling air exhaust duct and the position of the damper is aligned and set during installation to relieve air pressure in the room. The room is maintained at or below 50 °C (122 °F) by the ventilation/cooling system. Since system testing is unlikely to occur when the outdoor temperature is 50 °C (122 °F), system performance at design ambient conditions will be demonstrated through analysis of the performance at the tested conditions.

In response to RAI 505-4030, Question 9.5.8-23 regarding an apparent inconsistency between the intake air design temperature noted in Subsection B.3.3 of the "Qualification and Test Plan of Class 1E Gas Turbine Generator System" November 2009, (MUAP-07024-P(R1)) of -20ºC (-4°F), versus the plant site design temperature of -40ºC (-40°F) (0 percent exceedance), the applicant clarified that the former design temperature is applicable to the GTG room, whereas the outdoor (combustion air intake) design temperature for the GTG is -40ºC (-40°F) (0 percent exceedance) as stated in DCD Table 2.0-1, Key Site Parameters. The RAI response on February 1, 2010 is acceptable and does not require a revision to the DCD.

The GTG combustion air intake and exhaust system is provided with instrumentation consisting of a combustion air pressure indicator and exhaust gas temperature indicators. Thermocouples are used to sense turbine exhaust gas temperature and the turbine exhaust stack temperature. A digital temperature indicator with manual selector switch is located at the GTG control cabinet for selecting turbine exhaust stack temperature. At 100 percent rated load, the exhaust stack temperature is approximately 593°C + 28°C (1,100°F + 50°F). The EGTCAIES has no interlocks or alarm instrumentation.

According to DCD Tier 2 Section 9.5.8.3.A, the turbine exhaust is located "appropriately away" from the engine air intake to ensure that exhaust is not drawn into the inlet. SRP Section 9.5.8 states that the turbine exhaust should also be situated so that it does not circulate back to any potentially occupied part of the plant. The GTG exhaust gas discharge point, the ventilation exhaust for the GTG room, the ventilation supply air intake for the GTG room, and the combustion air intake for the GTG are all on the roof of the PS/B. The ventilation exhaust from the GTG room poses no hazard. The GTG exhaust discharge point is located approximately 18 feet above the edge of the intake openings for both the combustion air intake and the GTG room ventilation/cooling supply air intake for the A and B GTGs and approximately 10 feet above the intake openings for the C and D GTGs. The exhaust gas is directed vertically upward at high velocity and the exhaust gas temperature during operation is in excess of 538 °C (1,000 °F). This configuration and the GTG operating conditions ensure that exhaust gases will not be recirculated to the GTG intake or to the PS/B ventilation/cooling intake.

The DCD states that the hydrogen and nitrogen bulk storage facilities are 183 meters (600 feet) from the GTGs (no carbon dioxide is used on the site). Consequently, a release of these gases will not impact operation of the GTGs.

Subsection B.3.3 of the "Qualification and Test Plan of Class 1E Gas Turbine Generator System" (MUAP-07024-P) states that the allowable ambient air conditions for the GTG include a level of "foreign matters in the intake air" of less than 10μm (3.937E-4 inches). This size particulate can be contained in windblown dust. The applicant's response to RAI 618-4829, Question 9.5.8-27, dated November 4 2010, regarding the GTG combustion air intake design requirement for particulate control states that, according to the GTG manufacturer , the intake of particles larger than 10μm (3.937E-4 inches) is acceptable. According to the applicant, there are “hundreds of the same GTGs as for [the] US-APWR, designed specifically for emergency power supply, have been installed in Japan as a dedicated standby power and most of the Japanese users do not use a filter.” The RAI response dated November 4, 2010, also states that screens are installed at the inlet of the enclosure and inlet of gas turbine engine to prevent invasion of foreign objects. The screen opening size is approximately 5.1mm (0.2 inches). The applicant’s response also noted that air intake filters could reduce the reliability of the EPS as a result of possible plugging of the filter elements during operation.

The ingestion of large quantities of particulate matter over a long period of operation is expected to degrade the performance of the GTG and filters are appropriate for a machine that operates continuously. For a standby GTG used for emergency power, filters may not be needed and could possible reduce reliability as noted by the applicant. Any performance degradation will be detected by normal periodic testing and monitoring of GTG performance and will be corrected with normal maintenance. The staff does not expect the ingestion of particulates during post-DBA operation of the GTGs to cause a rapid deterioration of GTG performance to the extent that the design basis GTG output is unacceptably impacted. Organic particulate matter ingested will be burned in the GT combustor before reaching the turbine blades. A common practice in the past has been to introduce broken walnut shells into the combustion air intake to clean the GT compressor. The shell pieces are vaporized in the combustor after scrubbing the compressor blades. In addition, the US-APWR GT compressors are centrifugal type rather than axial type. The former is less impacted by the ingestion of particulates.

The design details provided in response to RAI 704-5248, Question 9.5.8-28 show a combustion air intake configuration that will reduce the ingestion of dust as well as snow and rain by providing an indirect air path. Consequently, the staff finds the US-APWR design acceptable.

Therefore the NRC staff finds that the EGTCAIES meets the requirements of GDC 17.

ITAAC: ITAAC items specific to the emergency power sources are listed in DCD Tier 1 Table 2.6.4-1. The items related to the EGTCAIES are as follows:

- Item 1 requires an inspection to verify that the as-built GTG system is functionally consistent with the description in DCD Section 2.6.4.1.

- Item 3 requires an inspection to ensure that each independent GTG has its own combustion air intake and exhaust system.

- Item 4 requires an inspection and test to verify that each emergency GTG support system is provided power by the same division of the Class 1E power system as the respective emergency GTG.

- Item 8 requires inspections and type tests, analyses or a combination of type tests and analyses to verify that the Seismic Category I EPS support system equipment and piping, including supports, can withstand seismic design basis loads without loss of safety function.

- Item 11 requires an inspection of the as-built Class 1E EPS to verify that the combustion air intake for each GTG is separated from the GTG exhaust discharge. The Design Commitment and Acceptance Criteria for this ITAAC state that the intake and exhaust are simply “separated.” This does not provide adequate verification that GT exhaust will not be drawn into the combustion air intake. This ITAAC should verify a design that provides adequate separation of the intake and exhaust in accordance with the design description in Tier 2 Section 9.5.8.3.A which states that the exhaust is “located appropriately away” from the intake, “thereby minimizing the chances of the turbine exhaust being drawn into the intake.” Therefore the staff requested the applicant in **RAI 754-5617, Question 14.3.6-22** to revise the Design Commitment and Acceptance Criteria accordingly. The applicant responded on July 15, 2011, stating that Tier 1 Table 2.6.4-1, ITAAC Item No. 11 Design Commitment and Acceptance Criteria will be revised to state that the location of the intake with respect to the exhaust will “minimize recirculation of exhaust gases to the air intake.” The staff finds the RAI response to be acceptable and considers RAI 754-5617, Question 14.3.6-22 to be closed. The inclusion of the proposed changes described in the response to RAI 754-5617, Question 14.3.6-22 is being tracked as **Confirmatory Item 9.5.8-2**.

- Item 12 Item 12 requires an inspection and test to ensure that each GTG system is independent of the other GTG systems and each of the four GTGs is located in a separate room of the PS/B. Revision 3 of Tier 1 of the US-APWR DCD replaced the statement that “Each Class 1E EPS is located in a separate room in the PS/B” with the statement that “The Class 1E EPSs are located in separate rooms in the PS/B.” This new statement in 12.b should similarly make it clear that <u>each</u> Class 1E EPS train is located in a separate room of the PS/B. This comment also applies to the description in Tier 1, Table 2.6.4-1, Item 12.b. Therefore the staff requested the applicant in **RAI 754-5617, Question 14.3.6-20** to revise the wording of this ITAAC to clarify the design. The applicant **responded on July 15, 2011**, that Tier 1, Table 2.6.4-1, ITAAC Item 12.b, Design Commitment, will be revised to state that “Each redundant division of Class 1E EPSs is located in a separate room of the PS/B.” The corresponding ITAAC Acceptance Criteria and Section 2.6.4.1 will be similarly revised. The staff finds the RAI response to be acceptable and considers RAI 754-5617, Question 14.3.6-20 to be closed. The inclusion of the proposed changes described in the response to RAI 754-5617, Question 14.3.6-20 is being tracked as **Confirmatory Item 9.5.4-1**.

- Item 19 requires an inspection to ensure that the as-built EGTCAIES is as described in DCD Tier 1 Section 2.6.4.2.

- Item 25 addresses the power supply for the fuel oil transfer pumps. There are other support system components that are also powered by the respective Class 1E division power supply, such as the ventilation/cooling supply and exhaust fans. Therefore the staff requested the applicant in **RAI 754-5617, Question 14.3.6-25** to revise the DCD to include all of the Class 1E powered support system components in this ITAAC, or provide separate ITAAC for them. The applicant responded on July 15, 2011, stating that the DCD Tier 1, Section 2.6.4.2, Design Description 25 and Table 2.6.4-1, ITAAC No. 25 will be revised to verify the Class 1E power supply to the EPS ventilation fans. The staff finds the RAI response to be acceptable and considers RAI 754-5617, Question 14.3.6-25 to be closed. The inclusion of the proposed changes described in the response to RAI 754-5617,Question 14.3.6-25 is being tracked as **Confirmatory Item 9.5.8-3**.

- Item 32 requires a test of each as-built GTG to demonstrate that the EGTCAIES is capable of supplying an adequate quantity of combustion air to the respective GT and of disposing of the exhaust gases when operating at 110 percent on nameplate rating.

TS and Initial Plant Test Program: There are no TS requirements specifically for the EGTCAIES. The staff finds this to be consistent with applicable NRC standard TS and is considered acceptable.

Preoperational testing of the GTGs is described in Section 14.2.12.1.44. The operation of the combustion air and exhaust functions will be demonstrated by successful GTG operation. The GTG room ventilation/cooling function of the EGTCAIES will also be demonstrated during the GTG continuous operation tests. Both room temperature and outdoor ambient temperature will be measured and recorded during the 24 hour continuous GTG operation tests. If the testing is not performed at the design basis outdoor ambient conditions, analyses will be performed to demonstrate that design indoor maximum temperatures will not be exceeded by an unacceptable amount when the outdoor ambient conditions are at their maximum. The tests described in the DCD for the EGTCAIES are acceptable to the staff.

9.5.8.5 Combined License Information Items

There are no COL information items pertaining to the gas turbine combustion air intake and exhaust system provided in DCD Tier 2, Section 9.5.8. This is found to be acceptable by the NRC staff pending resolution of the above RAI items.

9.5.8.6 Conclusions

Pending satisfactory resolution of **RAI 468-3360, Question 9.5.4-49, Open Item 9.5.4-1;** and closure of Confirmatory Items 9.5.4-1, 9.5.8-1, 9.5.8-2, and 9.5.8-3, the GTG combustion air intake and exhaust system design is acceptable and complies with applicable regulations as stated in the general design criteria of Appendix A to 10 CFR Part 50. Pending resolution of the RAIs, this conclusion is based on the technical evaluation that determined the DCD meets GDC 2, 4, 5, GDC 17, and 10 CFR 52.47(b)(1), as applicable.