9 AUXILIARY SYSTEMS

9.1 Fuel Storage and Handling

The staff's review of the AP1000 fuel storage and handling systems is provided in the following sections of this report: 9.1.1, New Fuel Storage; 9.1.2, Spent Fuel Storage; 9.1.3, Spent Fuel Pool Cooling and Purification; 9.1.4, Light Load Handling System (Related To Refueling); and 9.1.5, Overhead Heavy Load Handling Systems.

9.1.1 New Fuel Storage

The staff has reviewed the AP1000 advanced reactor's new fuel storage capability in accordance with Section 9.1.1, "New Fuel Storage," of NUREG-0800, "Standard Review Plan," (SRP). The staff's acceptance of the new fuel storage facility is contingent upon whether the design complies with the following requirements:

- General Design Criterion (GDC) 2, "Design Bases for Protection Against Natural Phenomena," as it relates to the ability of the facility and the structures housing it to withstand the effects of natural phenomena, such as earthquakes.

- GDC 5, "Sharing of Structures, Systems, and Components," as it relates to whether shared structures, systems, and components (SSCs) important to safety are capable of performing required safety functions.

- GDC 61, "Fuel Storage and Handling and Radioactivity Control," as it relates to the facility design for fuel storage.

- GDC 62, "Prevention of Criticality in Fuel Storage and Handling," as it relates to the prevention of criticality.

In accordance with SRP Section 9.1.1, compliance with GDC 2 is on the basis of adherence to the guidance of Regulatory Position C.1.1 of Regulatory Guide (RG) 1.29, "Seismic Design Classification," as it relates to the seismic classification of facility components. In accordance with SRP Section 9.1.1, specific criteria necessary to meet the requirements of GDC 61 and 62 are American Nuclear Society (ANS) 57.1-1980, "Design Requirements for Light Water Reactor Fuel Handling Systems," and ANS 57.3-1981, "Design Requirements for New LWR Fuel Storage Facilities," as they relate to preventing criticality and to aspects of the radiological design. In AP1000 Design Control Document (DCD) Tier 2 Section 9.1.1, "New Fuel Storage," the applicant provides the design bases, a description, and a safety evaluation of the new fuel storage arrangement for the AP1000 design.

In DCD Tier 2 Section 9.1.1.1, "Design Bases," the applicant states that the new fuel will be stored in a high-density rack that includes integral neutron absorbing material to maintain the required degree of subcriticality. The rack is designed to store fuel of the maximum design basis enrichment. The rack will include storage locations for 72 fuel assemblies. The rack array will have a center-to-center spacing of 27.7 cm (10.9 in). This spacing provides the

minimum separation between adjacent fuel assemblies that is sufficient to maintain a subcritical array, even if the building is flooded with unborated water or fire extinguishant aerosols, or during any design basis event. The new fuel storage facility will be located within the seismic Category I auxiliary building fuel handling area. The dry, unlined, approximately 5.2 m (17 ft) deep reinforced concrete pit is designed to support the new fuel storage rack. The rack will be supported by the pit floor and laterally supported at the rack top grid structure by the pit wall structures. The new fuel pit will normally be covered to prevent foreign objects from entering the new fuel storage rack.

In DCD Tier 2 Section 9.1.1.3, "Safety Evaluation," the applicant provides a safety evaluation to demonstrate that the new fuel storage rack design complies with the design bases. DCD Tier 2 Section 9.1.1.3 also states that the new fuel racks are purchased equipment, and that the purchase specification will require the vendor to perform a criticality analysis of the new fuel storage racks. The applicant considered normal and postulated accident conditions such as flooding with pure water and low density optimum moderator "misting." The following design features are used to minimize the possibility of these accidents:

- travel limits on handling equipment capable of carrying loads heavier than fuel components,

- rack designed for safe-shutdown earthquake (SSE) conditions,

- rack designed for dropped fuel assembly (and handling tool) conditions, and

- new fuel storage pit cover to protect new fuel from dropped objects and debris.

In addition, the new fuel pit is not accessed by the fuel handling machine or by the cask-handling crane. This precludes moving loads greater than that of the fuel components over new fuel assemblies.

The staff performed its review in accordance with the guidance and acceptance criteria in SRP Section 9.1.1. The staff directed its evaluation to determine whether or not the new fuel storage design complies with the requirements of GDC 2, 5, 61, and 62. On the basis of its review, the staff concludes that:

- The new fuel storage facility will be located within the seismic Category I auxiliary building fuel handling area in accordance with DCD Tier 2 Section 9.1.1.2, "Facilities Description." The new fuel storage rack is designed to meet the seismic Category I guidance of RG 1.29. Therefore, the staff finds that the new fuel storage facility meets the requirements of GDC 2.

- The AP1000 design can be used at either single-unit or multiple-unit sites. Nonetheless, in DCD Tier 2 Section 3.1.1, "Overall Requirements," the applicant states that the AP1000 design is a single-unit plant and that "if more than one unit is built on the same site, none of the safety-related systems will be shared." Should a multiple-unit site be proposed, the combined license (COL) applicant referencing the AP1000 design will be required to apply for the evaluation of the units' compliance with the requirements

of GDC 5, with respect to the capability of shared SSCs important to safety to perform their required safety functions.

- In DCD Tier 2 Section 9.1.1.3, the applicant states that the design of the rack is such that the effective multiplication factor (K_{eff}) remains less than or equal to 0.95 with new fuel of the maximum design basis enrichment. For a postulated accident condition of flooding the new fuel storage area with unborated water, K_{eff} will not exceed 0.98. DCD Tier 2 Section 4.3.2.6.1, "Criticality Design Method Outside the Reactor," states that the two principal methods of preventing criticality of fuel assemblies outside the reactor are to limit the fuel assembly array size and limit interaction by fixing the minimum separation between assemblies and/or inserting neutron poisons between assemblies. The design basis for preventing criticality outside the reactor is that, including uncertainties, there is a 95-percent probability at a 95-percent confidence level that the K_{eff} of the fuel assembly array will be less than 0.95, as recommended in ANS 57.1 and ANS 57.3. Therefore, the staff finds that the new fuel facility meets the requirements of GDC 61 and 62.

The staff has completed its review of the new fuel storage facility, including the seismic classification, and the protection of fuel inside the fuel storage pit. The new fuel storage facility is located within the seismic Category I auxiliary building fuel handling area. Accordingly, the staff finds this acceptable to meet the requirements of GDC 2 as it relates to the ability of the facility and the structures housing it to withstand the effects of natural phenomena, such as earthquakes. In addition, in that the AP1000 is a single unit design, and a COL applicant must comply with GDC 5 for a multiple-unit site, the staff finds that the requirements of GDC 5 are satisfied as it relates to whether shared SSCs important to safety are capable of performing required safety functions. Based on the analysis set forth above, the staff also finds that the requirements of GDC 61 are met as it relates to the facility design for fuel storage, and the requirements of GDC 62 are met as it relates to the prevention of criticality.

9.1.2 Spent Fuel Storage

The staff reviewed the spent fuel storage capability in accordance with SRP Section 9.1.2, "Spent Fuel Storage." The staff's acceptance of the spent fuel storage facility is on the basis of compliance with the following requirements:

- GDC 2, as it relates to the ability of the facility and the structures housing it to withstand the effects of natural phenomena, such as earthquakes, tornados, and hurricanes.

- GDC 4, "Environmental and Dynamic Effects Design Bases," as it relates to the ability of the facility and the structures housing it to withstand the effects of external missiles, and internally-generated missiles, pipe whip, jet impingement forces, and adverse environmental conditions associated with pipe breaks, such that safety functions will not be impaired.

- GDC 5, as it relates to whether shared SSCs important to safety are capable of performing required safety functions.

- GDC 61, as it relates to the facility design for fuel storage and handling of radioactive materials.

- GDC 62, as it relates to the prevention of criticality.

- GDC 63, "Monitoring Fuel and Waste Storage," as it relates to monitoring systems provided to detect conditions that could result in the loss of decay heat removal capabilities, to detect excessive radiation levels, and to initiate appropriate safety actions.

In accordance with SRP Section 9.1.1, compliance with the requirements of GDC 2 is on the basis of adherence to the guidance of Regulatory Position C.3 of RG 1.13, "Spent Fuel Storage Facility Design Basis;" the applicable portions of RG 1.29 and RG 1.117, "Tornado Design Classification;" and paragraphs 5.1.1, 5.1.3, 5.1.12, 5.3.2, and 5.3.4 of ANS 57.2-1976, "Design Objectives for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Stations." Compliance with the requirements of GDC 4 is on the basis of adherence to the guidance of Regulatory Position C.3 of RG 1.13, as well as RG 1.115, "Protection Against Low-Trajectory Turbine Missiles," and RG 1.117, and the appropriate paragraphs of ANS 57.2. Compliance with the requirements of GDC 61 is on the basis of adherence to the guidance of Positions C.1 and C.4 of RG 1.13, the appropriate paragraphs of ANS 57.2, and adherence to the fuel storage capacity guidelines noted in Subsection III.1 of SRP Section 9.1.2. Compliance with the requirements of GDC 62 is on the basis of adherence to the guidance of Positions C.1 and C.4 of RG 1.13, as well as the appropriate paragraphs of ANS 57.2. Finally, compliance with the requirements of GDC 63 is on the basis of adherence to the guidance of paragraph 5.4 of ANS 57.2.

In DCD Tier 2 Section 9.1.2, "Spent Fuel Storage," the applicant presents the design bases, facilities description, and a safety evaluation of the spent fuel storage arrangement. In addition, the applicant indicates that the spent fuel will be stored in high-density racks that include integral, neutron-absorbing material to maintain the required degree of subcriticality. The racks are designed to store fuel of the maximum design basis enrichment. The rack arrays will have a center-to-center spacing of 27.7 cm (10.9 in), and storage locations for 619 fuel assemblies. In addition, the rack module will contain integral storage locations for five defective fuel storage containers. The spent fuel storage racks will be seismic Category I, and will be located within the spent fuel pool. The racks will consist of an array of cells interconnected to each other at several elevations, and to supporting grid structures at the top and bottom elevations. The rack modules will be free-standing, neither anchored to the pool floor nor braced to the pool wall.

The spent fuel storage facility (spent fuel pool) will be located within the seismic Category I auxiliary building fuel handling area. The DCD states that the facility will be protected from the effects of natural phenomena, such as earthquakes, wind, tornados, floods, and external missiles. DCD Tier 2 Section 9.1.1.2, "Facilities Description," also indicated, and the staff agrees, that internally-generated missiles are of no concern because the fuel handling area does not contain any credible sources of internally-generated missiles. As a result, the staff determined that the spent fuel storage design meets the applicable guidance of RGs 1.115 and 1.117.

In DCD Tier 2 Section 9.1.2.3, "Safety Evaluation," the applicant provides a safety evaluation to demonstrate that the spent-fuel storage rack design and location comply with its design bases. The safety evaluation includes postulated accidents and criticality safety assumptions. The following postulated accidents were considered:

- fuel handling accidents (e.g., dropped fuel assembly)
- uplift force on the fuel racks
- a misplaced fuel assembly

The following design features will be used to minimize the possibility of these accidents:

- The cask handling crane (capable of carrying loads heavier than the fuel components) is prevented, by design, from carrying loads over the fuel storage area.

- The racks are designed for SSE conditions.

- The racks are designed for dropped fuel assembly (and handling tool) conditions.

- The fuel handling machine is designed to seismic Category I requirements.

In DCD Tier 2 Section 9.1.2.3, "Safety Evaluation," the applicant states that the design of the racks is such that K_{eff} remains less than or equal to 0.95 under design basis conditions, including fuel handling accidents. DCD Tier 2 Section 4.3.2.6.1, "Criticality Design Method Outside the Reactor," states that the two principal methods of preventing criticality of fuel assemblies outside the reactor are to limit the fuel assembly array size and limit interaction by fixing the minimum separation between assemblies and/or inserting neutron poisons between assemblies. The design basis for preventing criticality outside the reactor is that, including uncertainties, there is a 95-percent probability at a 95-percent confidence level that the K_{eff} of the fuel assembly array will be less than 0.95, as recommended in ANS 57.1 and ANS 57.3. Therefore, the staff finds that the spent fuel storage design meets the requirements of GDC 61 and 62.

Compliance with GDC 63 is demonstrated as discussed in Section 9.1.3 of this report.

The staff based its review of DCD Tier 2 Section 9.1.2 on the guidance and acceptance criteria in SRP Section 9.1.2. The staff directed its evaluation at determining whether or not the spent fuel storage facility complies with the requirements of GDC 2, 4, 5, 61, 62, and 63. Acceptability for meeting these criteria is on the basis of conformance to Positions C.1, C.3, and C.4 of RG 1.13; applicable portions of RG 1.29, RG 1.115, and RG 1.117; and the appropriate paragraphs of ANS 57.2. On the basis of its review, the staff concludes that:

- In accordance with Regulatory Postion C.3 of RG 1.13, heavy loads are prevented, by design, from being lifted over the spent fuel pool. In addition, 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.

- In accordance with Regulatory Postion C.1 of RG 1.13, RG 1.29, and paragraphs 5.1.1, 5.1.3, 5.1.12 and 5.3.2 of ANS 57.2, the spent fuel storage racks are in the spent fuel

storage pool, which is located within the seismic Category I auxiliary building fuel handling area. The auxiliary building is designed to maintain its structural integrity following a SSE and to perform its intended function following a postulated event such as a fire. The spent fuel pool and racks are designed to seismic Category I requirements.

- In accordance with Regulatory Postion C.4 of RG 1.13, the spent fuel storage facility is located within the seismic Category I auxiliary building fuel handling area. This portion of the auxiliary building is served by the radiologically controlled area ventilation system (VAS). The VAS consists of a fuel handling area ventilation subsystem and an auxiliary/annex building ventilation subsystem. As stated in DCD Tier 2 Table 3.2-3, the VAS is non-seismic. The VAS serves no safety-related function. The staff's review of the VAS is discussed in Section 9.4 of this report.

As described above, the staff reached the following conclusions. The staff found that the spent fuel storage design is in compliance with GDC 2, as it relates to the ability of the facility and the structures housing it to withstand the effects of natural phenomena, such as earthquakes, tornados, and hurricanes. The staff found that the spent fuel storage design is in compliance with GDC 4, as it relates to the ability of the facility and the structures housing it to withstand the effects of external missiles, pipe whip, jet impingement forces, and adverse environmental conditions associated with pipe breaks, such that safety functions will not be impaired. DCD Tier 2 Section 9.1.1.2.1.E states, and the staff agrees, that internally-generated missiles are of no concern because the fuel handling area does not contain any credible sources of internally-generated missiles.

Also, in that the AP1000 is a single unit design, and a COL applicant must comply with GDC 5 for a multiple-unit site, the staff finds that the requirements of GDC 5 are satisfied as it relates to whether shared SSCs important to safety are capable of performing required safety functions. The staff found that the spent fuel storage design is in compliance with GDC 61, as it relates to the facility design for fuel storage and handling radioactive materials, and GDC 62, as it relates to the prevention of criticality. In addition, the spent fuel storage design is in compliance with GDC 63, as discussed in Section 9.1.3 of this report, as it relates to monitoring systems provided to detect conditions that could result in the loss of decay heat removal capabilities, to detect excessive radiation levels, and to initiate appropriate safety actions.

9.1.3 Spent Fuel Pool Cooling and Pool Purification

The staff has reviewed the spent fuel pool cooling and purification system (SFPCPS) in accordance with SRP Section 9.1.3, "Spent Fuel Pool Cooling and Cleanup System." The staff's acceptance of the SFPCPS design is on the basis of design compliance with the following SRP guidance:

- GDC 2, as it relates to the ability of system and the structures housing it to withstand the effects of natural phenomena, such as earthquakes, tornados, and hurricanes.

- GDC 4, as it relates to the ability of the system and the structures housing it to withstand the effects of external missiles.

- GDC 5, as it relates to whether shared SSCs important to safety are capable of performing required safety functions.

- GDC 44, "Cooling Water," as it relates to the following:

  - the system's ability to transfer heat loads from safety-related SSCs to a heat sink under both normal operating and accident conditions,

  - suitable redundancy of components so that safety functions can be performed assuming a single active failure of a component coincident with a loss of offsite power (LOOP) event, and

  - the system's ability to isolate components, systems, or piping so that the system's safety function will not be compromised.

- GDC 45, "Inspection of Cooling Water System," as it relates to allowing periodic inspection of safety-related components and equipment.

- GDC 46, "Testing of Cooling Water System," as it relates to allowing operational functional testing of safety-related systems or components to ensure structural integrity and system leak tightness, operability, and adequate performance of active system components, as well as the capability of the integrated system to perform the required functions during normal, shutdown, and accident conditions.

- GDC 61, as it relates to the following system design criteria for fuel storage and handling of radioactive materials:

  - capability for periodic testing of components important to safety,

  - provisions for containment,

  - provisions for decay heat removal,

  - capability to prevent reduction in fuel storage coolant inventory under accident conditions in accordance with Regulatory Position C.6 of RG 1.13, and

  - capability and capacity to remove corrosion products, radioactive materials, and impurities from the pool water and reduce occupational exposures.

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

- Title 10 of the Code of Federal Regulations (10 CFR) 20.1101(b), as it relates to radiation doses being kept as low as reasonably achievable (ALARA).

Compliance with the requirements of GDC 2 is founded on adherence to the guidance of Positions C.1, C.2, C.6, and C.8 of RG 1.13, as well as Regulatory Position C.1 (safety-related

portions of the system) and Regulatory Position C.2 (non-safety-related portions of the system) of RG 1.29. Compliance with the requirements of GDC 4 is founded on adherence to the guidance of Regulatory Position C.2 of RG 1.13. Compliance with the requirements of GDC 44 is founded on adherence to the recommendations of Branch Technical Position (BTP) Auxiliary Systems Branch (ASB) 9-2, "Residual Decay Energy for Light Water Reactors for Long-Term Cooling," for calculating the heat loads, the assumptions set forth in Item 1.h of Subsection III of SRP Section 9.1.3, and the pool temperature limitations identified in Item 1.d of Subsection III of SRP Section 9.1.3. Compliance with the requirements of 10 CFR 20.1101(b) is founded on adherence to the guidance of Positions C.2(f)(2) and C.2.f(3) of RG 8.8, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable."

In DCD Tier 2 Section 9.1.3.2, "System Description," the applicant states that the spent fuel pool cooling system is a non-safety-related system. The safety-related function of cooling and shielding the fuel in the spent fuel pool is performed by the water in the pool. A simplified sketch of the system is provided as DCD Tier 2 Figure 9.1-5.

The applicant states that the spent fuel pool cooling system consists of two mechanical trains of equipment. Each train consists of one spent fuel pool pump, one spent fuel pool heat exchanger, one spent fuel pool demineralizer, and one spent fuel pool filter. The two trains of equipment share common suction and discharge headers. In addition, the spent fuel pool cooling system is comprised of piping, valves, and instrumentation necessary for system operation. Either train of equipment can be operated to perform any of the functions required of the spent fuel pool cooling system independently of the other train. One train is continuously cooling and purifying the spent fuel pool while the other train is available for water transfers or in-containment refueling water storage tank (IRWST) purification, or is aligned as a backup to the operating train of equipment.

Both trains are designed to process spent fuel pool water. Each pump takes suction from the common suction header and discharges directly to its respective heat exchanger. The outlet piping branches into parallel lines. The purification branch is designed to process approximately 20 percent of the cooling flow while the bypass branch passes the remaining. Each purification branch is routed directly to a spent fuel pool demineralizer. The outlet of the demineralizer is routed to a spent fuel pool filter. The outlet of the filter is then connected to the bypass branch, which forms a common line that connects to the discharge header.

The spent fuel pool cooling system suction header is connected to the spent fuel pool at two locations. The main suction line connects to the spent fuel pool at an elevation 0.6 m (2 ft) below the normal water level of the pool. Two skimmer connections take suction from the water surface of the spent fuel pool. This suction arrangement prevents the spent fuel pool from inadvertently being drained below a level that would prevent the water in the spent fuel pool from performing its safety functions. This arrangement also eliminates the need for a separate skimmer circuit arrangement.

The spent fuel pool pump suction header is connected to the IRWST and the refueling cavity. This enables purification of the IRWST or the refueling cavity, and allows for the transfer of water between the IRWST and the refueling cavity. The spent fuel pool pump suction header is also connected to the fuel transfer canal and the cask loading pit. These connections are

provided primarily for transferring water from the fuel transfer canal to the cask loading pit. Water that is normally stored in the fuel transfer canal can be sent to the cask loading pit and from the cask loading pit back to the transfer canal.

The spent fuel pool is initially filled for use with water having a boron concentration of approximately 2500 ppm. Demineralized water can be added for makeup purposes, including replacement of evaporative losses, from the demineralized water transfer and storage system. Boron may be added to the spent fuel pool from the chemical and volume control system (CVS).

The spent fuel pool water may be separated from the water in the transfer canal by a gate. The gate enables the transfer canal to be drained to permit maintenance of the fuel transfer equipment.

The staff reviewed the SFPCPS for compliance with the requirements of GDC 2, 4, 5, 44, 45, 46, 61, 63 and 10 CFR 20.1101(b), as referenced in SRP Section 9.1.3. The staff found that the AP1000 SFPCPS is not a safety-related system and is not required to operate following events such as earthquakes, fires, passive failures, or multiple active failures. The SFPCPS has the safety-related functions of containment isolation and providing safety-related connections for temporary emergency makeup to the spent fuel pool for cooling. Spent fuel pool makeup for a long-term station blackout can be provided through seismically qualified safety-related makeup connections from the passive containment cooling system. These connections are located in an area of the auxiliary building that can be accessed without exposing operating personnel to excessive levels of radiation or adverse environmental conditions during boiling of the pool.

The spent fuel pool is designed such that water is maintained above the spent fuel assemblies for at least seven days following a loss of the spent fuel pool cooling system. In accordance with the design, the minimum water level to achieve sufficient cooling is the sub-cooled, collapsed level (without vapor voids) required to cover the top of the fuel assemblies. Therefore, the applicable portion of the requirements of GDC 2 are that the structure housing the system must have the ability to withstand the effects of natural phenomena, such as earthquakes, tornados, and hurricanes. In this regard, the spent fuel pool is located in a seismic Category I building in the fuel handling area. The staff determined that the SFPCPS is protected from natural phenomena and is in compliance with Regulatory Positions C.1, C.2, C.6, and C.8 of RG 1.13 and Regulatory Positions C.1 and C.2 of RG 1.29. Thus, the staff concludes that the SFPCPS complies with the requirements of GDC 2. The SFPCPS is also in compliance with the applicable portions of the following requirements:

- GDC 4, as it relates to the ability of the structure housing the system to withstand the effects of external missiles. The spent fuel pool is located in a seismic Category I building. Therefore, the SFPCPS is protected from external missiles. Thus, the staff concludes that the SFPCPS complies with Regulatory Position C.4 of RG 1.13, and thereby the requirements of GDC 4.

- GDC 5, as it relates to whether shared SSCs important to safety are capable of performing required safety functions. In that the AP1000 is a single unit design, and a COL applicant must comply with GDC 5 for a multiple-unit site, the staff finds that the SFPCPS complies with the requirements of GDC 5.

- GDC 44, as it relates to the system's ability to transfer heat loads from safety-related SSCs to a heat sink under both normal operating and accident conditions. There are no safety-related SSCs involved in the spent fuel pool system under normal operating conditions; however, during accident conditions, the spent fuel pool is designed to cool by boiling and transferring the heat to the atmosphere. Therefore, the SFPCPS meets the intent of BTP ASB 9-2 , and thereby meets the intent of GDC 44.

- GDC 45, as it relates to allowing periodic inspection of safety-related components and equipment. The spent pool cooling system is not a safety-related system; however, DCD Tier 2 Section 9.1.3.6.2 states that periodic visual inspections and preventive maintenance will be performed. Therefore, the SFPCPS meets the intent of GDC 45.

- GDC 46, as it relates to the capability of the system to perform required functions during normal, shutdown, and accident situations. As discussed above, the SFPCPS meets the required functions of containment isolation and providing safety-related connections for temporary emergency makeup for spent fuel pool cooling. Therefore, the SFPCPS meets the intent of GDC 46.

- GDC 61, as it relates to provisions for decay heat removal; the capability to prevent reduction in fuel storage coolant inventory under accident conditions; and the capability and capacity to remove fission products, radioactive materials, and impurities from the pool water and reduce occupational exposures. Under accident conditions the system is designed to provide makeup for seven days. In addition, the purification system is found acceptable to remove fission products and radioactive materials from the pool water thereby reducing occupational exposures. Thus, the staff concludes that the SFPCPS complies with the requirements of GDC 61.

- GDC 63, as it relates to monitoring systems provided to detect conditions that could result in the loss of decay heat removal capabilities, detect excessive radiation levels, and initiate appropriate safety actions. The AP1000 design provides acceptable instrumentation to measure temperature, pressure, flow and level in the spent fuel pool. The design also limits exposure rates at the surface of the spent fuel pool to less than 2.5 mrem/hr. This corresponds to an activity level in the water of approximately 0.005 microcurie per gram for the dominant gamma-emitting isotopes at the time of refueling. The spent fuel pool cooling system flow rate for one train shall be more than that necessary to provide two water volume changes in 24 hours for the spent fuel pool water. Therefore, the staff concludes that the SFPCPS complies with the requirements of GDC 63.

- The requirements of 10 CFR 20.110(b), as it relates to the design of the fuel pool cooling system purification capability to minimize the occupational radiation exposure, and thereby keep radiation doses as low as reasonably achievable. The staff finds the spent fuel pool cooling system provides a purification and filtration system design that will minimize the occupational radiation exposure, and thereby keep radiation doses as low as reasonably achievable and thereby meeting the intent of RG 8.8. Thus, the staff concludes that the SFPCPS complies with the requirements of 10 CFR 20.110(b).

On the basis of the above discussion, the staff concludes that the information provided by the applicant regarding the design of the SFPCPS is acceptable.

9.1.4 Light Load Handling System (Related To Refueling)

The staff reviewed the light load handling system (LLHS) in accordance with SRP Section 9.1.4, "Light Load Handling System." Staff acceptance of the design of the system is contingent on design compliance with the following requirements:

- GDC 2, as it relates to the ability of SSCs to withstand the effects of earthquakes.
- GDC 5, as it relates to whether shared SSCs important to safety are capable of performing required safety functions.
- GDC 61, as it relates to a radioactivity release as a result of fuel damage and the avoidance of excessive personnel radiation exposure.
- GDC 62, as it relates to criticality accidents.

In accordance with SRP Section 9.1.4, compliance with the requirements of GDC 2 is on the basis of adherence to the guidance of Positions C.1 and C.6 of RG 1.13, as well as Positions C.1 and C.2 of RG 1.29. In accordance with SRP Section 9.1.4, compliance with the requirements of GDC 61 is on the basis of adherence to the guidance of Regulatory Position C.3 of RG 1.13, as well as ANS 57.1/ANSI-N208. In accordance with SRP Section 9.1.4, compliance with the requirements of GDC 62 is on the basis of adherence to the guidance of Regulatory Position C.3 of RG 1.13, as well as ANS 57.1/ANSI N208.

In DCD Tier 2 Section 9.1.4.2, the applicant states that the LLHS consists of the equipment and structures needed for the refueling operation. This equipment is comprised of fuel assemblies, core component and reactor component hoisting equipment, handling equipment, and a dual-basket fuel transfer system. The following structures are associated with the fuel handling equipment:

- refueling cavity
- transfer canal
- fuel transfer tube
- spent fuel pool
- cask loading area
- new fuel storage area
- new fuel receiving and inspection area

The fuel handling equipment is designed to handle the spent fuel assemblies underwater from the time they leave the reactor vessel until they are placed in a container for shipment from the site. As described below, underwater transfer of spent fuel assemblies provides an effective and transparent radiation shield, as well as a reliable cooling medium for removal of decay heat. The boric acid concentration in the water is sufficient to preclude criticality.

The associated fuel handling structures may be generally divided into two areas:

- the refueling cavity, which is flooded only during plant shutdown for refueling
- the spent fuel pool and transfer canal, which are kept full of water

The refueling cavity and fuel storage area are connected by the fuel transfer tube, which is fitted with a quick-opening hatch on the canal end and a valve on the fuel storage area end. The hatch is in place, except during refueling, to provide containment integrity. Fuel is carried through the tube on an underwater transfer car.

Fuel is moved between the reactor vessel and the fuel transfer system by the refueling machine. The fuel transfer system is used to move up to two fuel assemblies at a time between the containment building and the auxiliary building fuel handling area. After a fuel assembly is placed in the fuel container, the lifting arm pivots the fuel assembly to the horizontal position for passage through the seismic Category I fuel transfer tube, in accordance with Regulatory Positions C.1 and C.6 of RG 1.13 and Regulatory Positions C.1 and C.2 of RG 1.29. After the transfer car transports the fuel assembly through the transfer tube, the lifting arm at that end of the tube pivots the assembly to a vertical position so that the assembly can be lifted out of the fuel container.

In the fuel handling area, fuel assemblies are moved about by the seismic Category I fuel handling machine, in accordance with Regulatory Positions C.1 and C.6 of RG 1.13 and Regulatory Positions C.1 and C.2 of RG 1.29. Initially, a short tool is used to handle new fuel assemblies, but the new fuel elevator must be used to lower the assembly to a depth at which the fuel handling machine can place the new fuel assemblies into or out of the spent fuel storage racks.

New fuel assemblies received for refueling are removed one at a time from the shipping container and moved into the new fuel assembly inspection area using the seismic Category II new fuel jib crane.

DCD Tier 2 Section 9.1.4.1.1, "Safety Design Basis," states that in the event of a SSE, handling equipment cannot fail in such a manner as to prevent the required function of seismic Category I equipment. Based on the above discussion, the staff concludes that the LLHS complies with the requirements of GDC 2.

The transfer car controls for the fuel transfer system are located in the fuel handling area. Therefore, conditions in the containment are not visible to the operator. The transfer car permissive switch allows the fuel transfer system containment operator to exercise some control over car movement, if conditions visible to the operator warrant such control.

In accordance with Regulatory Position C.3 of RG 1.13 and ANS 57.1/ANSI-N208, an interlock on the fuel transfer system prevents the upender from being moved from the horizontal to the vertical position if the transfer car has not reached the end of its travel. An interlock on the transfer tube valve permits transfer car operation only when the transfer tube valve position switch indicates that the valve is fully open.

The fuel transfer system is also interlocked with the refueling machine. Whenever the transfer car is located in the refueling cavity, the fuel transfer system cannot be operated unless the refueling machine mast is in the fully retracted position, the refueling machine is over the core, or the gripper is released and inside the core.

On the spent fuel pool side, the fuel transfer system is interlocked with the fuel handling machine. The fuel transfer system cannot be operated until the fuel handling machine is moved away from the fuel transfer system area.

Fuel handling tools and equipment handled over an open reactor vessel are designed to prevent inadvertent decoupling from machine hooks. In addition, lifting rigs are pinned to the machine hook, and safety latches are provided on hook supporting tools. Tools required for handling internal reactor components are designed with the following fail-safe features that prevent disengagement of the component in the event of operating mechanism malfunction:

- The air cylinders actuating the gripper mechanism are equipped with backup springs that close the gripper in the event of loss of air to the cylinder. Air-operated valves are equipped with safety locking rings to prevent inadvertent actuation.

- When the fingers are latched, the actuating handle is positively locked, preventing inadvertent actuation. The tool is preoperationally tested at 125 percent of the weight of one fuel assembly.

During spent fuel transfer, the gamma dose rate at the surface of the water is 20 mrem/hour or less. This is accomplished by maintaining a minimum of 3 m (10 ft) of water above the top of the active fuel height during handling operations. The three fuel handling devices used to lift spent fuel assemblies are the refueling machine, the fuel handling machine, and the spent fuel handling tool. Both the refueling machine and fuel handling machine contain positive stops that prevent the fuel assembly from being raised above a safe shielding height.

DCD Tier 2 Section 9.1.4.1.1 states that the fuel handling devices have provisions to avoid dropping or jamming of fuel assemblies during transfer operation and that the handling equipment have provisions to avoid dropping of fuel handling devices during the fuel transfer operation. Based on the above discussion, the staff concludes that the LLHS meets the intent of GDC 61 and 62.

The staff found that the LLHS for the AP1000 design is in compliance with GDC 2, as it relates to the ability of SSCs to withstand the effects of an earthquake. It is in compliance with GDC, 5 as it relates to whether shared SSCs important to safety are capable of performing required safety functions, in accordance with DCD Tier 2 Section 3.1.1, which states that "The AP1000 is a single-unit plant. If more that one unit were built on the same site, none of the safety-related systems would be shared." The LLHS is also in compliance with the intent of GDC 61 and 62, as related to a radioactivity release as a result of fuel damage and the avoidance of excessive personnel radiation exposure, and criticality accidents respectively.

9.1.5 Overhead Heavy Load Handling Systems

The staff's acceptance of the design of a heavy load handling system (HLHS) is contingent on compliance with the following requirements:

- GDC 2, as it relates to the ability of SSCs to withstand the effects of natural phenomena such as earthquakes.
- GDC 4, as it relates to the protection of safety-related equipment from the effects of internally-generated missiles (i.e., dropped loads).
- GDC 5, as it relates to whether shared SSCs important to safety are capable of performing their required safety functions.
- GDC 61, as it relates to the safe handling and storage of fuel.

Compliance with the requirements of GDC 2 is on the basis of adherence to the guidance of Positions C.1 and C.6 of RG 1.13, as well as Positions C.1 and C.2 of RG 1.29. Compliance with the requirements of GDC 4 is on the basis of adherence to the guidance of Positions C.3 and C.5 of RG 1.13. Other guidelines used in the evaluation of this system include NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants," issued July 1980.

For the AP1000 design, the applicant defines a heavy load to be a load that weighs more than the combined weight [about 1406 kg (3100 lbs)] of a fuel assembly with a rod cluster control, and the associated handling device (consisting of the inner mast of the fuel handling machine and the fuel gripper assembly). This equipment is part of the mechanical handling system (MHS) and is located throughout the plant. HLHSs are generally classified as non-safety-related, non-seismic systems. The components of single-failure-proof systems necessary to prevent uncontrolled lowering of a critical load are classified as safety-related.

The containment polar crane, the equipment hatch hoist system, and the maintenance hatch hoist system are single-failure-proof systems. They are classified as seismic Category I, and are designed to support a critical load during and after a SSE, and thereby are in compliance with Regulatory Positions C.1 and C.6 of RG 1.13 and Regulatory Positions C.1 and C.2 of RG 1.29. A critical load is a heavy load that, if dropped, could cause unacceptable damage to reactor fuel elements, or a loss of safe shutdown or decay heat removal capability. Therefore, the staff concludes that the HLHS complies with the requirements of GDC 2.

For the AP1000 design, the plant arrangement and the design of HLHSs are predicated on the following criteria:

- In accordance with Regulatory Positions C.3 and C.5 of RG 1.13, to the extent practicable, heavy loads are not carried over or near safety-related components, including irradiated fuel and safe shutdown components. Safe load paths are designed for heavy load handling in safety-related areas.
- In accordance with the guidance of NUREG-0612:

- the likelihood of a load drop is extremely small (that is, the handling system is single-failure-proof), or the consequences of a postulated load drop are within acceptable limits;
- single-failure-proof systems can stop and hold a critical load following the credible failure of a single component; and
- single-failure-proof systems can support a critical load during and after a SSE.

Except for the containment polar crane, the equipment hatch hoist system, and the maintenance hatch hoist system, the HLHSs are not single-failure-proof. The DCD states that overhead cranes are designed according to American Society of Mechanical Engineers (ASME) NOG-1, "Rules for Construction of Overhead and Gantry Cranes." Other cranes and hoists handling heavy loads are designed according to the applicable ANSI standard.

In DCD Tier 2 Section 9.1.5.3, the applicant states that, for the polar crane and the equipment and maintenance hatch hoist systems, redundancy is provided for load bearing components such as hoisting ropes, sheaves, equalizer assembly, hooks, and holding brakes. These systems are designed to support a critical load during and after a SSE.

The spent fuel shipping cask storage pit is separated from the spent fuel pool. The spent fuel shipping cask crane cannot move over the spent fuel pool because the crane rails do not extend over the pool. Mechanical stops prevent the spent fuel shipping cask crane from going beyond the ends of the rails.

In DCD Tier 2 Section 9.1.5.3, the applicant also states that a heavy load analysis is performed to evaluate postulated load drops from HLHSs located in safety-related areas of the plant, specifically the nuclear island. The applicant further states that no evaluations are required for critical loads handled by the single-failure-proof containment polar crane, equipment hatch hoist, or maintenance hatch hoist, because a load drop is unlikely. In accordance with NUREG-0612, the heavy load analysis is meant to confirm that a postulated load drop does not cause unacceptable damage to reactor fuel elements, or a loss of safe shutdown or decay heat removal capability. Based on the above discussion, the staff concludes that the HLHS complies with the requirements of GDC 61.

As described above, the staff concludes that the design of the AP1000 HLHSs is in compliance with the requirements of GDC 2, as it relates to the ability of SSCs to withstand the effects of natural phenomena such as earthquakes. It is also in compliance with GDC 4, as it relates to protection of safety-related equipment from the effects of internally-generated missiles, because in DCD Tier 2 Section 9.1.1.2.1.E, the applicant states that the fuel handling area does not contain any credible sources of internally-generated missiles. In that the AP1000 is a single unit design, and a COL applicant must comply with GDC 5 for a multiple-unit site, the staff finds that the HLHSs complies with the requirements of GDC 5, relating to whether shared SSCs important to safety are capable of performing required safety functions. The design of the HLHSs are also in compliance with GDC 61, as it relates to the safe handling and storage of fuel.

9.2 Water Systems

The staff's review of the AP1000 water systems is provided in the following sections: 9.2.1, Service Water System; 9.2.2, Component Cooling Water System; 9.2.3, Demineralized Water Treatment System; 9.2.4, Demineralized Water Transfer and Storage System; 9.2.5, Potable Water System; 9.2.6, Sanitary Drainage System; 9.2.7, Central Chilled Water System; 9.2.8, Turbine Building Closed Cooling System; 9.2.9, Waste Water System; and 9.2.10, Hot Water Heating System.

The AP1000 design can be used at either single-unit or multiple-unit sites. Nonetheless, in DCD Tier 2 Section 3.1.1, the applicant states that the AP1000 design is a single-unit plant, if more than one unit is built on the same site, none of the "safety-related systems" will be shared. Should a multiple-unit site be proposed, the COL applicant referencing the AP1000 design will be required to apply for the evaluation of the units' compliance with the requirements of GDC 5, "Sharing of Structures, Systems, and Components," with respect to the capability of shared SSCs to perform their required safety functions.

9.2.1 Service Water System

The staff reviewed the design of the service water system (SWS) in accordance with SRP Section 9.2.1, "Station Service Water System." However, the SWS for the AP1000 differs from that of the traditional pressurized water reactor (PWR) designs in that the AP1000 SWS is completely a non-safety-related system and serves no safety-related function. In traditional PWRs, portions of the SWS were required to perform safety-related functions. The reason that the AP1000 SWS is a non-safety-related system is that the SWS removes heat only from the component cooling water system (CCS) which is not a safety-related system. The staff's evaluation of the CCS being non-safety-related is provided in Section 9.2.2 of this report. Therefore, the portions of SRP Section 9.2.1 that apply to safety-related systems are not applicable for the AP1000 SWS. As for the non-safety-related SWS meeting the requirements of GDC 2, as it relates to structures and systems being capable of withstanding the effects of natural phenomena, acceptance is predicated on meeting the guidance of the portions of Regulatory Position C.2 of RG 1.29, regarding non-safety-related systems.

The SWS supplies cooling water to remove heat from the CCS heat exchangers which are located in the turbine building. The system consists of two 100-percent capacity cooling trains of components and piping for normal power operation. Each train includes one service water pump, one component cooling heat exchanger, one strainer, and one cooling tower cell. Cross connections between the trains at upstream and downstream of the heat exchangers are provided to allow either service water pump to supply cooling water to either heat exchanger, and to allow either heat exchanger to discharge to either cooling tower. The cooling tower, cooling tower fans, pumps, and applicable valves of the SWS are classified as AP1000 Class D, Seismic Category NS (non-seismic). In order to provide reasonable assurance that the SWS is operable during anticipated events, the applicant includes it in the AP1000 programs, "Investment Protection Short-Term Availability Controls" and "Design Reliability Assurance Program."

The investment protection short-term availability controls (IPSAC), as described in AP1000 DCD Tier 2 Section 16.3, "Investment Protection," define:

- equipment that should be operable
- operational modes when the equipment should be operable
- testing and inspections that should be used to demonstrate the equipment's operability
- operational modes that should be used for planned maintenance operations
- remedial actions that should be taken if the equipment is not operable

The design reliability assurance program (DRAP), as described in AP1000 DCD Tier 2 Section 17.4, "Design Reliability Assurance Program," provides confidence that availability and reliability of the equipment are maintained throughout plant life through the maintenance rule (10 CFR 50.65, "Requirements for monitoring the effectiveness of maintenance at nuclear power plants").

The service water pumps are centrifugal pumps driven by electric motors, each pump has a design flow rate of 29.8 m /min (8000 gpm). These pumps take suction from the service water pump basin through fixed screens to the pump suction piping. The service water pumps discharge through strainers to the CCS heat exchangers. The heated SWS water from the heat exchangers is passed through the discharge piping to the mechanical draft cooling tower, where the system heat is rejected. The cool water, collected in the tower basin, provides the source for the suction of service water pumps.

The power supplies for the SWS pumps and associated active components are from independent and non-safety-related electrical buses. Each bus is capable of being supplied from one of two onsite standby diesel generators. In the event of loss of normal ac power, the SWS pumps and cooling tower fans, along with the associated motor operated valves, are automatically loaded onto their associated diesel buses. The SWS, therefore, continues to provide cooling water to the required components during the loss of normal ac power events.

The SWS operates during startup, normal plant operation, normal plant cooldown, and refueling, and is available following a LOOP event. Under normal plant operation, one of the two SWS trains removes the heat from one of the two CCS heat exchangers and discharges it to the cooling tower. The standby train is automatically started on combined low-flow and low-pressure values when the operating train fails. During accident conditions, the SWS remains in the same operating modes as for normal operations. During plant startup, shutdown, and refueling, both SWS trains are used.

A radiation monitor with a high alarm is provided to monitor the service water blowdown flow for detection of potentially radioactive leakage into the SWS from CCS heat exchangers. Provisions are also available for taking local fluid samples. If radioactive fluid is detected in the SWS, cooling tower blowdown flow can be isolated by remote manual control.

With regard to sufficient net positive suction head (NPSH) available for SWS pumps and the potential for water hammer, in DCD Tier 2 Section 9.2.1.2.1, "General Description," the applicant stated that temperatures in the system are moderate and that the pressure of the system is kept above saturation at all locations. The system pressure and temperature relation, and other design features of the system arrangement and control of valves, ensure sufficient

NPSH available for SWS pumps and minimize the potential for thermodynamic or transient water hammer.

The maximum ambient air wet bulb temperature specified in DCD Tier 2 Chapter 2, "Site Characteristics," for site interface parameters is 26.67°C (80°F). This maximum wet bulb temperature may be applied to most U.S. plant sites. Actual site-specific data will dictate design parameters of the cooling tower. Specific site conditions that exceed the 26.67°C (80°F) wet bulb temperature should be accommodated by specific site analysis to adjust cooling system capability.

In DCD Tier 2 Section 9.2.1.1.1, the applicant states that failure of the SWS or its components will not affect the ability of any other safety-related systems to perform their intended safety functions. Postulated breaks in the SWS piping will not impact safety-related components because the SWS is not located in the vicinity of any safety-related equipment, and the water from the break will not reach any safety-related equipment. Therefore, the staff finds that the SWS complies with GDC 2 by meeting the guidance of Regulatory Position C.2 of RG 1.29 for ensuring that the non-safety-related SWS could withstand the effects of earthquakes without affecting safety-related systems.

As described above, the staff has reviewed the SWS in accordance with SRP Section 9.2.1. Because the AP1000 SWS is not safety-related, and its failure does not lead to the failure of any safety systems, the requirements of GDCs 4, 44, 45, and 46 and the guidance of SRP Section 9.2.1, regarding safety-related systems, do not apply.

On the basis of the above review, the staff determines that the SWS design meets the applicable provisions described in SRP Section 9.2.1. Also, the service water system/components are classified as AP1000 Class D system; and included in the AP1000 IPSAC and DRAP programs. Therefore, the staff finds the SWS acceptable.

9.2.2 Component Cooling Water System

The staff reviewed the design of the CCS in accordance with the guidance of SRP Section 9.2.2, "Reactor Auxiliary Cooling Water Systems."

The CCS is a non-safety-related, closed loop cooling system that transfers heat from various nonsafety-related plant components to the SWS during normal plant operation. It also removes heat from various safety-related components (i.e. reactor cooling pumps, CVS letdown heat exchangers, and normal residual heat removal system (RNS) heat exchangers and pumps). However, none of these safety-related components requires cooling water to perform its safety-related functions. The safety-related functions of these components are limited to maintaining primary coolant system integrity and providing reactor coolant pump coast-down capability. Safety-related cooldown and decay heat removal functions are provided by the passive core cooling system (PXS) and passive containment cooling system (PCS).

The CCS provides a barrier to prevent the release of radioactivity from plant components, that handle radioactive fluid being cooled, and the environment. The CCS also provides a barrier against leakage of service water into primary containment and reactor systems.

The CCS consists of two trains and one component cooling water surge tank. Each train consists of one component cooling water pump and one component cooling water heat exchanger, as well as associated valves, piping, and instrumentation. The component cooling water surge tank, which accommodates thermal expansion and contraction, is connected to a shared portion of the return header. The two trains of equipment take suction from a single return header. The discharge of each heat exchanger is routed directly to the common supply header. Component cooling water is distributed to the components by this single supply/return header. Loads inside containment are automatically isolated in response to a safety injection signal which trips the reactor coolant pumps. Individual components, except the reactor coolant pumps, can be isolated locally to permit maintenance, while supplying the remaining components with cooling water.

The two component cooling water pumps are horizontal, centrifugal pumps. Each pump has a design flow rate of 30.2 m /min (8000 gpm). The pumps are redundant for normal operation heat loads. Both pumps are required for the design basis cooldown, however, an extended cooldown can be achieved with only one pump in operation. Each pump can be aligned to either heat exchanger. Component cooling water in the heat exchanger is provided by the SWS, and is maintained at a higher pressure than the service water to prevent in-leakage from service water into the system. Three motor-operated isolation valves and a check valve provide containment isolation for the supply and return CCS lines that penetrate the containment barrier. The motor-operated valves are normally open, and are closed upon receipt of a safety injection signal.

The power supplies for the CCS pumps and associated active components are independent and from non-safety-related electrical buses. In the event of loss of normal ac power, the CCS pumps are automatically loaded on the standby diesel. The CCS, therefore, continues to provide cooling water to the required components during the loss of normal ac power events.

The CCS provides cooling water to the safety-related components identified above during normal plant operation, and normal reactor shutdown and cooldown. Safety-related cooldown and decay heat removal functions following a loss of coolant accident (LOCA) are provided by the PXS and PCS. Therefore, the CCS serves no safety-related function, except for containment isolation. Segments of the CCS piping that penetrate the containment and the associated containment isolation valves are safety-related and perform a safety-related containment isolation function, therefore, these segments are designed to accommodate environmental and dynamic effects associated with pipe breaks and satisfy GDC 4. The evaluation of the protection against the effects of pipe breaks is evaluated in Section 3.6.1 of this report. Refer also to Section 3.4.1 of this report for an evaluation of the protection against internal flooding.

DCD Tier 2 Table 3.2-3 classifies CCS pumps and valves as AP1000 Class D, Seismic Category NS (with the exception of containment isolation valves). In addition, the CCS pumps and valves are included in the AP1000 IPSAC and DRAP programs. The containment penetration isolation valves are Safety Class B, as is the pipe between the isolation valves.

Based on its review, the staff agrees with the applicant that the CCS does not perform any safety-related function except for containment isolation. Therefore, portions of SRP Section 9.2.2 that apply to safety-related systems are not applicable for the AP1000 CCS.

In DCD Tier 2 Section 9.2.2.1.1, the applicant states that failure of the CCS or its components will not affect the ability of safety-related systems to perform their intended safety functions. This conforms to the guidance of Regulatory Position C.2 of RG 1.29. Therefore, the staff concludes that the CCS complies with the requirements of GDC 2.

GDC 44, 45, and 46 do not apply to the CCS because the CCS heat loads are not safety-related.

The operating temperature of the CCS components will normally be well below 93.3°C (200°F), and the pressure will be maintained above atmospheric. Because the CCS will normally operate at temperatures and pressures that prevent formation of steam bubbles, water hammer issues will be avoided.

On the basis of the above review, the staff determines that the CCS design meets the applicable provisions described in SRP Section 9.2.2. Also, the CCS are included in the AP1000 IPSAC and DRAP programs. Therefore, the staff finds the CCS acceptable.

9.2.3 Demineralized Water Treatment System

The staff reviewed DCD Tier 2 Section 9.2.3, "Demineralized Water Treatment System," in accordance with SRP Section 9.2.3, "Demineralized Water Makeup System." The demineralized water treatment system (DTS) is acceptable if the system is capable of providing the required supply of reactor coolant purity water to the demineralized water transfer and storage system (DWS). The DTS does not perform any safety-related function or accident mitigation, and its failure would not reduce the safety of the plant.

9.2.3.1 Summary of Technical Information

The AP1000 DTS receives water from the raw water system (RWS), processes this water to remove ionic impurities, and provides demineralized water to the DWS.

This system consists of the following major components:

- two reverse osmosis (RO) feed pumps,
- two 100 percent RO units running in series, and
- one electrodeionization (EDI) unit for secondary demineralization.

The system functional specifications for the DTS are provided in DCD Tier 2 Table 9.2.3-1, "Guidelines for Demineralized Water (Measured at the Outlet of the Demineralized Water Treatment System)."

9.2.3.2 Staff Evaluation

The staff evaluated the design and operational requirements of the DTS and concluded that it includes all components associated with the system from the source of raw water to a discharge to the DWS. In addition, the staff reviewed the system functional specifications provided in Table 9.2.3-1 in providing the appropriate reactor water coolant purity during all conditions of plant operation. However, high concentrations of halogens and sulfates present in the system

can accelerate the corrosion of components in the DTS. Therefore, by letter dated September 24, 2002, the staff sent RAI 281.002 requesting the applicant to provide the maximum allowable concentrations of halogens and sulfates present in the system. By letter dated December 6, 2002, the applicant responded that the range of halogens and sulfates present in this system are as shown in Table 9.2.3-1 with the maximum values of 1 ppb for chloride and sulfate.

The staff concluded that these maximum values for chloride and sulfate are appropriate since these values ensure adequate reactor coolant purity during all conditions of plant operation to keep the levels of corrosion low.

9.2.3.3 Conclusion

The design of the DTS includes the components and piping needed to collect and treat raw water and supply it to the DWS. The staff's review has determined that the applicant's proposed design criteria and design bases for the DTS is sufficient to supply adequate reactor coolant purity water during all conditions of plant operation.

9.2.4 Demineralized Water Transfer and Storage System

The staff reviewed the DWS in accordance with the guidance of SRP Section 9.2.3. Specifically, the staff reviewed the system to ensure its capability to provide the required supply of reactor coolant pure makeup water to all systems. Acceptability of the DWS is based upon meeting the guidance of Regulatory Position C.2 of RG 1.29 for non-safety-related systems, the failure of which could affect the functioning of any safety-related system. Conformance with the acceptance criteria of the SRP forms the basis for concluding that the DWS satisfies the applicable requirements of GDC 2, as it relates to the system being capable of withstanding the effects of earthquakes.

The DWS is a non-safety-related system that supplies demineralized water (through the demineralized water storage tank) to fill the condensate storage tank and to the plant systems that demand a demineralized water supply. The DWS primarily consists of: a 379 m^3 (100,000 gallons) capacity demineralized water storage tank; a 1835 m^3 (485,000 gallons) capacity condensate storage tank; two motor-driven demineralized water transfer pumps; and two catalytic oxygen reduction units.

The demineralized water storage tank, which receives water from the DTS, supplies demineralized water to the makeup pumps of the CVS during startup. A low level alarm on the tank signals the plant operator to isolate demands on the tank, other than CVS supply. The condensate storage tank serves as a reservoir to supply or receive condensate as required by the condenser hotwell level control system. In the event of loss of main feedwater when the deaerator storage tank is not available, the condensate storage tank will serve as a backup water supply for the startup feedwater pumps. The condensate storage tank will provide sufficient water to the startup feedwater system to permit eight hours of hot standby operation. Adequate isolation is provided at all makeup demineralized water connections to safety-related systems.

Two catalytic oxygen reduction units are used to degasify the stored demineralized water. One unit is provided for the demineralized water distribution system and the other unit is provided at the condensate storage tank. A check valve, in conjunction with a block valve, is used to prevent backflow of fluids from systems that interface with the DWS. The applicant stated that the condensate storage tank normally contains no significant radioactive contaminants.

The DWS is classified as AP1000 Class D, Seismic Category NS, with the exception of containment isolation valves. The containment penetration isolation valves are Safety Class B, as is the pipe between the isolation valves.

The system has no safety-related function other than containment isolation, and its failure does not affect the ability of safety-related systems to perform their intended safety functions. Therefore, the design conforms to the guideline of Regulatory Position C.2 of RG 1.29. Regulatory Position C.1 of RG 1.29 does not apply to the DWS because the system performs no safety-related function.

Based on its review, the staff concludes that the DWS has the capability to provide an adequate supply of reactor coolant pure makeup water to all plant systems during all modes of plant operation. The design of the system complies with Regulatory Position C.2 of RG 1.29 concerning its seismic classification and satisfies the applicable requirements of GDC 2 with respect to the need for protection against natural phenomena. Therefore, the staff concludes that the DWS meets the guidance of SRP Section 9.2.3, and is acceptable.

9.2.5 Potable Water System

The staff reviewed the potable water system (PWS) in accordance with SRP Section 9.2.4, "Potable and Sanitary Water Systems." Conformance with the acceptance criteria of the SRP forms the basis for concluding that the PWS satisfies GDC 60, "Control of Releases of Radioactive Materials to the Environment," as it relates to design provisions provided to control the release of water containing radioactive material and prevent contamination of the potable water.

The PWS is a non-safety-related system that is designed to provide clean water from the raw water system for domestic use and human consumption. The system consists of: a carbon steel tank with a capacity less than 37.85 m^3 (10,000 gallons); two motor-driven potable water pumps; a system jockey pump; a distribution header around the power block; hot water storage heaters; and necessary interconnecting piping and valves.

The potable water is treated to prevent harmful physiological effects and its bacteriological and chemical quality conforms to the requirements of the Environmental Protection Agency (EPA) "National Primary Drinking Water Standards" (40 CFR Part 141). Disinfection is provided upstream of the potable water storage tank by the turbine island chemical feed system to disinfect the raw water supply into the tank. The PWS distribution is in compliance with 29 CFR 1910, "Occupational Safety and Health Standards, Part 141."

In the DCD, the applicant states that no interconnections exist between the PWS and any potentially radioactive system or any system using water for purposes other than domestic water service. To prevent contamination of the PWS from other systems supplied by the RWS,

the common supply from the onsite RWS will be designed to use either an air gap or reduced-pressure-zone type backflow prevention device. Branches of the PWS supplying plumbing fixtures, located in areas of potential radiological hazard where access is restricted, are provided with the reduced-pressure-zone type backflow prevention devices. Therefore, the design of the SDS satisfies GDC 60, with respect to prevention of contamination by the radioactive waste drain system.

On the basis of its review, the staff concludes that the design of the PWS, as described above, satisfies GDC 60 with respect to prevention of contamination by radioactive water. Therefore, the staff concludes that the potable water system meets the guidance of SRP Section 9.2.4 and is acceptable.

9.2.6 Sanitary Drainage System

The staff reviewed the sanitary drainage system (SDS) in accordance with SRP Section 9.2.4. Conformance with the acceptance criteria of the SRP forms the basis for concluding that the SDS satisfies GDC 60, as it relates to design provisions provided to control the release of radioactive materials to the environment.

The SDS is a non-safety-related system that collects sanitary wastes from plant restrooms and locker room facilities in the turbine building, auxiliary building, and annex building for treatment, dilution, and discharge. The system is designed to accommodate 0.1 m^3 (25 gallon) per person per day, for up to 500 persons during a 24-hour period. The system will be tested and inspected in accordance with the Uniform Plumbing Code Section 318, issued 2000. The SDS components, such as branch lines, lift stations, and waste treatment plant are site-specific and outside the scope of the AP1000 design.

In the DCD, the applicant states that the SDS does not serve the facilities in radiologically controlled areas and has no connection to the systems having the potential for containing radioactive material. Therefore, the design of the SDS satisfies GDC 60, with respect to prevention of contamination by the radioactive waste drain system.

Based on its review, the staff concludes that the design of the sanitary drainage system, as described above, satisfies GDC 60 with respect to control of the release of water containing radioactive material. Therefore, the staff concludes that the sanitary drainage system meets the guidance of SRP Section 9.2.4, and is acceptable.

9.2.7 Central Chilled Water System

The staff reviewed the central chilled water system (VWS) in accordance with SRP Section 9.2.2. Conformance with the acceptance criteria of the SRP forms the basis for concluding that the central chilled water system satisfies GDC 2, 44, 45, and 46.

The VWS is a non-safety-related system that provides chilled water to the cooling coils of the supply air handling units and unit coolers of the following plant heating, ventilation, and air conditioning (HVAC) systems during normal modes of plant operation:

- radiologically controlled area ventilation system
- containment recirculation cooling system
- containment air filtration system
- health physics/control access area HVAC system
- radwaste building ventilation system
- Annex I and auxiliary building nonradioactive ventilation system

The VWS also supplies chilled water to the components of the liquid radwaste system, gaseous radwaste system, containment leakrate-test system components, secondary sampling system, the portable and mobile radwaste system, and the electrical switchgear room and personal work area air handling units of the turbine building ventilation system.

The plant HVAC systems require chilled water as a cooling medium to satisfy the ambient temperature requirements for the plant. The cooling water to the chiller condensers is supplied from the CCS. The VWS is divided into two closed-loop subsystems (i.e., the high-capacity subsystem and the low-capacity subsystem).

The high-capacity subsystem, located in the turbine building, is the primary system to provide chilled water to the above major HVAC systems and other plant equipment requiring chilled water cooling. The high-capacity subsystem consists of: two 100-percent capacity chilled water pumps; two 100-percent capacity water-cooled chillers; a chemical feed tank; an expansion tank; and associated valves, piping, and instrumentation.

The high-capacity subsystem is arranged in two parallel trains with common supply and return headers. Each train includes one pump and one chiller. A cross-connection at the discharge of each pump is provided to allow for either pump to feed either chiller. During normal operation of the subsystem, one pump/chiller train is required to provide chilled water to plant components at a normal temperature of 4.4°C (40°F). The standby train would be started manually if the operating train fails. The design cooling capacity of the high-capacity subsystem is founded on the ambient design temperature of 38°C (100°F) dry bulb and 29°C (77°F) coincident wet bulb maximum and -23°C (-10°F) minimum.

The low-capacity subsystem, located in the auxiliary building, is designed to provide chilled water to the HVAC systems in the main control room, the technical support center, and the Class 1E electrical equipment room. The low-capacity subsystem consists of two 100-percent capacity chilled water loops, each with: a chilled water pump; an air-cooled chiller; an expansion tank; and associated valves, piping, and instrumentation

This subsystem is arranged in two independent trains with separate supply and return headers. This subsystem configuration provides 100 percent redundancy during normal plant operation and during a LOOP. During normal operation of the subsystem, one pump/chiller train is required to supply chilled water to the components of the nuclear island nonradioactive ventilation system and the radiologically controlled area ventilation system at a normal temperature of 4.4°C (40°F). In the event that one train is inoperable, the standby train can be

manually aligned to supply chilled water to these components. The design cooling-capacity for the low capacity subsystem is founded on the ambient design temperatures of 46°C (115°F) dry bulb and 26.7°C (80°F) coincident wet bulb maximum.

The VWS is classified as AP1000 Class D, Seismic Category NS, with the exception of containment isolation valves. The containment penetration isolation valves are Safety Class B, as is the pipe between the isolation valves.

The VWS has no safety-related function other than containment isolation, and its failure does not affect the ability of safety-related systems to perform their intended safety functions. Therefore, the design conforms to the guideline of Regulatory Position C.2 of RG 1.29. Compliance with Regulatory Position C.1 of RG 1.29 does not apply to the VWS because the system performs no safety-related function.

The VWS is not required to achieve safe shutdown or to mitigate any postulated accidents and serves no safety-related function, except for the portion of the system lines routed into the containment that require containment isolation. The high-capacity subsystem supply and return lines that penetrate the containment are provided with two air-operated containment isolation valves. These valves automatically close upon receipt of a containment isolation signal. A bypass mode, with indication in the control room, is also provided to restore containment recirculation system cooling during containment isolation.

Because the VWS has no safety-related function, other than containment isolation, and a failure of the system will not impact the operation of safety-related equipment, the requirements of GDC 44, as related to the capability to transfer heat loads from safety-related systems; GDC 45, as related to inservice inspection of safety-related components and equipment; and GDC 46, as related to operational functional testing of safety-related systems or components, are not applicable.

Based on its review, the staff concludes that the safety-related portion of the system (the containment penetrations and the isolation valves) complies with Regulatory Position C.1 of RG 1.29 on the basis that they are designed in accordance with containment isolation provisions. Because the system serves no safety-related function and its failure as a result of a SSE will not reduce the functioning of any safety-related plant features, the non-safety-related portion of the system complies with Regulatory Position C.2 of RG 1.29. Therefore, the staff concludes that the design of the central chilled water system meets the guidance of SRP Section 9.2.2, and is acceptable.

9.2.8 Turbine Building Closed Cooling System

The staff reviewed the design of the turbine building closed cooling system (TCS) in accordance with applicable provisions of SRP Section 9.2.2. With respect to GDC 2, as related to structures and systems being capable of withstanding the effects of earthquakes, acceptance is based on meeting the guidance of Regulatory Position C.2 of RG 1.29 for non-safety-related portions of the system. Because the TCS is not safety-related, the requirements of GDC 4, 44, 45, and 46, as reflected in the guidance of SRP Section 9.2.2 are not applicable.

The TCS is a closed-loop cooling water system that provides chemically treated, demineralized water for the removal of heat from non-safety-related heat exchangers in the turbine building, and rejects the heat to the circulating water system (CWS). The TCS which has no safety-related function and is classified as AP1000 Class D, Seismic NS, consists of: two 100-percent capacity pumps; three 50-percent capacity heat exchangers; a surge tank; a chemical addition tank; and associated piping, valves, and instrumentation and controls

The TCS complies with GDC 2 by adhering to the guidance of Regulatory Position C.2 of RG 1.29 for ensuring that failures of TCS during seismic events will not affect the performance of any safety-related systems or components. TCS piping and components are located entirely within the turbine building. No safety-related equipment is located in the turbine building. Therefore, the failure of the TCS (including the effects of jet impingement and flooding) cannot lead to the failure of any safety-related SSCs.

Because the TCS is not safety-related and its failure does not lead to the failure of any safety systems, the TCS meets the requirements of GDC 2, on the basis of meeting Regulatory Position C.2 of RG 1.29, as described above. Therefore, the staff concludes that the design of the TCS meets the guidance of SRP, and is acceptable.

9.2.9 Waste Water System

The staff reviewed the waste water system (WWS) in accordance with SRP Section 9.3.3, "Equipment and Floor Drainage System." Conformance with the acceptance criteria of the SRP forms the basis for concluding that the WWS satisfies the requirements of GDC 2, 4, and 60.

The WWS is a non-safety-related system that collects and processes the waste water from the equipment and floor drains in the nonradioactive building areas during plant operation and outages. Wastes from the turbine building floor and equipment drains are collected in the two turbine building drain tanks for temporary storage. Drainage from the diesel generator building sumps, the auxiliary building nonradioactive sump and the annex building sump is also collected in the turbine building sumps. The waste water from either of the two drain tanks is then pumped to an oil separator for removal of oily waste. The oil separator has a small reservoir for storage of the separated oily waste which flows by gravity to a waste oil storage tank. The waste oil storage tank provides temporary storage prior to removal by truck for offsite disposal. The waste water from the oil separator flows by gravity to a waste water retention basin, if required, for settling of suspended solids and treatment before discharge. The effluent in the retention basin is pumped to either the cooling tower basin or to plant outfall, depending on the quality of the water in the waste water retention basin.

In the event that radioactivity is present in the drain tanks, a manual three-way valve allows for the waste water to be diverted from the drain tanks to the liquid radwaste system (WLS) for processing and disposal. A radiation monitor is installed on the common discharge piping of the drain tank pumps to detect and isolate the contaminated waste water. The radiation monitor will alarm upon detecting radioactivity in the waste water, and trip the drain tank pumps and the waste water retention basin pumps. The applicant states in the DCD that provisions for sampling the drain tanks for radioactive contamination is included in the design. Therefore, the staff concludes that the design of the WWS satisfies GDC 60 with respect to control of the release of water from the WWS containing radioactive material.

In DCD Tier 2 Section 9.2.9.5, the applicant indicates that level controls will be provided for the building drain tanks and the waste water retention basin to prevent overflow of these waste water collection points. High water level alarms will alert the operator to take action. Effects of flooding resulting from system pipe breaks or component failures in the non-radiologically controlled areas (NRCAs) are discussed in Section 3.4.1.2, "Internal Flooding" of this report. The WWS pipe breaks or component failures were determined not be the dominant sources that may cause internal flood in the NRCAs. In Section 3.4.1.2 of this report the staff concludes that the applicant properly identified safety-related equipment and flood hazards in the NRCAs and provided adequate means of protecting safety-related equipment from the identified flood hazards in the NRCAs. Therefore, the staff concludes that the design of the WWS complies with GDC 4 with respect to flood protection.

The staff also finds that the WWS design complies with GDC 2, as related to the ability of withstanding the effects of earthquakes. Compliance with GDC 2 is predicated on meeting the guidance of Regulatory Positions C.1 and C.2 of RG 1.29 concerning its seismic classification. The WWS need not comply with Regulatory Position C.1 because the system is not safety-related. Instead, the WWS complies with the guidelines of Regulatory Position C.2 of RG 1.29 because failure of the system during a SSE will not reduce the function of any safety-related plant features.

Based on its review, the staff concludes that the WWS meets the NRC regulations set forth in the following review criteria:

- GDC 2 with respect to protecting the system against natural phenomena.
- GDC 4, with respect to preventing flooding that could result in adverse effects on safety-related systems.
- GDC 60, with respect to preventing the inadvertent transfer of contaminated fluids to the noncontaminated drainage system for disposal.

Therefore, the design of the WWS meets the guidance of SRP Section 9.3.3, and is acceptable.

9.2.10 Hot Water Heating System

The hot water heating system (VYS) supplies heated water to selected non-safety air handling units and unit heaters in the plant during cold weather operation, and to the containment recirculation fan coil units during plant outages in cold weather. During a loss of normal ac power, the system will be powered from the onsite diesel generators. The VYS serves no safety-related function and therefore has no nuclear safety design basis. The VYS and its associated equipment are classified as AP1000 Class D, seismic Category NS. There are no GDC or SRP guidelines that are directly applicable to the review of the VYS, therefore, the staff's review of the VYS is based on the relevant regulatory guidance and industry standards that apply to the evaluation of the VYS.

The VYS which is a closed loop system consists of: a heat transfer package (including two 50-percent capacity heat exchangers; two 50-percent capacity system pumps; a surge tank;

and a chemical feed tank); and a distribution system to the various HVAC systems and unit heaters. The VYS is manually actuated and may operate when the site ambient temperature is 23°C (73°F) or below. The system uses steam source from the high-pressure turbine crossunder piping to heat water by transferring the heat energy through the heat exchangers. During a plant outage, the auxiliary steam taken from the auxiliary boiler is used to heat water. The heated water is pumped to the hot water coils of the various HVAC systems and unit heaters. Condensate from the heat exchanger is level controlled and drained to the main condenser or auxiliary boiler feedwater system. The surge tank will maintain the minimum system pressure above the saturation conditions at the pump suction. The chemical feed tank has the capability to provide chemical mixing in the system for corrosion control. The makeup water for the VYS is supplied by the DWS.

Based on its review and the facts that the VYS is a non-safety-related system, has no safety-related function, and interfaces with only non-safety related systems, the staff concludes that the requirements of GDC 5, 44, 45, and 46, and Appendix B of 10 CFR Part 50 are not applicable to the VYS.

The VYS is a high energy system. Piping is shared inside the containment between VYS and VWS. During normal plant operation, the VYS is isolated from VWS and containment. The applicant stated that the VYS piping is generally excluded from safety-related plant areas outside the containment. Piping of this system routed in the safety-related areas is 2.54 cm (1 in) and smaller, and is not evaluated for pipe ruptures.

The staff’s evaluation of the protection against the dynamic effects associated with the postulated rupture of piping is addressed in Section 3.6 of this report.

The staff’s evaluation of the effects of flooding caused by postulated rupture of piping on the safe shutdown capability of the plant is addressed in Section 3.4.1 of this report.

Based on its review, the staff concludes that:

- The VYS meets GDC 2 because it serves no safety-related function and Regulatory Position C.2 of RG 1.29, because it interfaces with only non-safety-related systems; and its failure will not affect the functions of the safety-related systems. Regulatory Position C.1 of RG 1.29 is not applicable to the VYS because it is not a safety-related system.

- The VYS, as designed to industrial standards as a non-seismic Category and classified as AP1000 Class D, is acceptable because it is not a safety-related system.

Therefore, the staff concludes that the design of the VYS is acceptable.

9.3 Process Auxiliaries

The staff’s review of the AP1000 process auxiliaries is provided in the following sections: 9.3.1, Compressed and Instrument Air System; 9.3.2, Plant Gas System; 9.3.3, Primary Sampling System; 9.3.4, Secondary Sampling System; 9.3.5, Equipment and Floor Drainage System; 9.3.6, Chemical and Volume Control System; and 9.4, Air-Conditioning, Heating, Cooling, and Ventilation System.

9.3.1 Compressed and Instrument Air System

The staff reviewed the compressed and instrument air system (CAS) in accordance with the guidance of SRP Section 9.3.1, "Compressed Air System." Conformance with the acceptance criteria of the SRP forms the basis for concluding whether the instrument air subsystem of the CAS satisfies the following requirements:

- GDC 1, "Quality Standards and Records," as it relates to systems and components being designed, fabricated, and tested to quality standards in accordance with the importance of the safety functions to be performed.

- GDC 2, as it relates to the capability of safety-related CAS components to withstand the effects of earthquakes.

- GDC 5, as it relates to the capability of shared systems and components to perform required safety functions.

The AP1000 design can be used at either single-unit or multiple-unit sites. Nonetheless, in DCD Tier 2 Section 3.1.1, the applicant states that the AP1000 design is a single-unit plant; if more than one unit is built on the same site, none of the safety-related systems will be shared. Should a multiple-unit site be proposed, the COL applicant referencing the AP1000 design will be required to apply for the evaluation of the units' compliance with the requirements of GDC 5, "Sharing of Structures, Systems, and Components," with respect to the capability of shared SSCs important to safety to perform their required safety functions.

As identified in DCD Tier 2 Table 3.2-3, the CAS components, with the exception of the containment penetration piping and isolation valves, are classified as non-nuclear safety and non-seismic. The quality assurance requirements of Appendix B to 10 CFR Part 50 do not apply. The containment penetration piping and isolation valves are classified as safety Class 2, seismic Category I, quality group B. The system description, components, and flow diagrams are provided in DCD Tier 2 Section 9.3.1, Tables 9.3.1-1 to 9.3.1-4, and Figure 9.3.1-1, respectively.

The CAS consists of the following subsystems:

- the instrument air system,
- the service air system, and
- the high-pressure air systems

The CAS serves no safety-related function other than containment isolation. The major components of the CAS are located in the turbine building.

Generic Issue (GI) 43, "Reliability of Air Systems," deals with safety aspects of air systems in nuclear power plants. GI 43 was resolved by the issuance of Generic Letter (GL) 88-14, "Instrument Air Supply System Problems Affecting Safety-Related Equipment," which requested licensees and applicants to review the recommendations of NUREG-1275, "Operating Experience Feedback Report," and perform a design and operations verification of the system.

A complete discussion of how the AP1000 design addresses GI 43 is provided in Section 20.3 of this report.

9.3.1.1 Instrument Air Subsystem

The instrument air subsystem provides high-quality instrument air, as specified in the ANSI/Instrument Society of America (ISA) S7.3-1981, "Quality Standard for Instrument Air," which is specified in SRP Section 9.3.1. The intake filters for the instrument air subsystem prevent particulates 10 microns and larger from entering the air supply to the compressors.

Sample points are provided downstream of the air dryers in the instrument air subsystem to monitor the air quality supplied by each compressor. Periodic checks are made to assure high quality instrument air as specified in the ANSI/ISA S7.3 standard.

Air-operated valves that are essential for safe shutdown and accident mitigation are designed to actuate to the fail-safe position upon loss of air pressure. A list of the safety-related air-operated valves supplied by the instrument air subsystem are identified in DCD Tier 2 Table 9.3.1-1. There are no safety-related air-operated valves that rely on safety-related air accumulators to actuate to the fail-safe position upon loss of air pressure.

DCD Tier 2 Section 9.3.1.4 states that, during the initial plant testing prior to reactor startup, safety systems utilizing instrument air will be tested to verify fail-safe operation of air-operated valves upon sudden loss of instrument air or gradual reduction of air pressure, as described in RG 1.68.3, "Preoperational Testing of Instrument and Control Air Systems." In addition, DCD Tier 2 Section 14.2.9.4.10 states that testing is performed to verify the fail-safe positioning of safety-related air-operated valves for sudden loss of instrument air or gradual loss of pressure, as described in DCD Tier 2 Section 9.3.1.4.

Therefore, the AP1000 design complies with the guidance of ANSI/ISA-S7.3, as it relates to supplying clean, dry, oil-free air to safety-related components, and the guidance of RG 1.68.3, as it relates to the testing of the CAS. On this basis, the staff concludes that the CAS complies with the requirements of GDC 1, with respect to systems and components important to safety being designed, fabricated, and tested to quality standards commensurate with the importance of the safety functions to be performed.

9.3.1.2 Service Air Subsystem

Plant breathing air requirements are satisfied by using the service air subsystem as a supply source. Portable, individually packaged, air purification equipment can be attached to any service air subsystem outlet to improve the service air quality to a minimum of Quality Verification Level D as defined in ANSI/CGA G-7.1. The breathing air purification package consists of replaceable cartridge-type filters, a pressure regulator, carbon monoxide monitoring equipment, air supply hoses, and air supply devices. Carbon monoxide is controlled by a catalytic conversion to carbon dioxide within the package. The service air subsystem is not connected to the instrument air subsystem.

9.3.1.3 High-Pressure Air Subsystem

The air compressor of the high pressure air subsystem has an integral air purification system to produce air for high-pressure applications, This integral high-pressure air purification system utilizes a series of replaceable cartridge-type filters to produce breathing quality air. The high-pressure air subsystem supplies Quality Verification Level E air, as defined in ANSI/CGA G-7.1, and periodic checks on the high-pressure air compressor are made on a regular basis to verify that the breathing air meets these standards. Carbon monoxide is controlled by a catalytic conversion to carbon dioxide within the package. Breathing air connections to the high-pressure air subsystem are incompatible with the breathing air connections of the service air subsystem to prevent attaching the portable air purification equipment to the high pressure air subsystem.

The onsite standby diesel generators provide an alternate source of electrical power for the high-pressure air compressor.

The high-pressure air subsystem is classified as a high-energy system. The high-pressure compressor and receiver are located in the turbine building, which contains no safety-related equipment or structures. Air piping in safety-related areas is one inch or less in diameter and the dynamic consequences of a rupture are not required to be analyzed, This subsystem is not required to operate following a design-basis accident, nor is it used for safe shutdown of the plant.

9.3.1.4 Conclusion

Compliance with Regulatory Position C.1 of RG 1.29 is not applicable because the CAS, with the exception of the inner and outer containment isolation valves and lines in between, is non-safety-related. Instead, the CAS complies with Regulatory Position C.2 of RG 1.29, because the CAS is not required to remain functional, and its failure as a result of a SSE will not reduce the functioning of any plant feature included in items 1.A through 1.Q of Regulatory Position C.1 of RG 1.29, to an unacceptable safety level. The SSCs are non-nuclear safety class, but the structure housing the CAS (turbine building) is designated as seismic Category II and is designed and constructed so that the SSE will not cause any failure in a manner that would adversely affect other safety systems, as stated in DCD Tier 2 Section 3.2.1 and Table 3.2-1. Therefore, the system complies with GDC 2, as it relates to the ability of the system to withstand the effects of earthquakes.

On the basis of the above review, the staff concludes that the CAS complies with GDC 1, 2, and 5, as referenced in SRP Section 9.3.1 and is, therefore, acceptable.

9.3.2 Plant Gas System

The plant gas system (PGS) provides hydrogen, carbon dioxide, and nitrogen gases to plant systems as required. Other gases, such as oxygen, methane, acetylene, and argon are supplied in smaller individual containers and are not supplied by the PGS. The hydrogen portion of the PGS supplies hydrogen to the main plant electrical generator for cooling as well as to other plant auxiliary systems. The carbon dioxide portion stores and supplies carbon dioxide to the generator to purge hydrogen and air during layup or plant outages. The nitrogen

portion of the PGS supplies nitrogen for pressurizing, blanketing, and purging various plant components.

The PGS is required for normal plant operation and startup of the plant. The PGS serves no safety-related function. Failure of the system does not compromise any safety-related system, nor does it prevent safe reactor shutdown.

The main steam isolation valves (MSIVs) and the main feedwater isolation valves (MFIVs) are safety-related valves that use compressed nitrogen stored within the valve operators as the motive force to close the valves. Note 21 on DCD Tier 2 Figure 10.3.2-1 specifies that the MSIVs and MFIVs are pneumatic-hydraulically actuated with a sealed nitrogen accumulator that provides the stored energy to close the valve. Nitrogen makeup for these valves (if needed) is provided from portable high-pressure nitrogen bottles, which are part of the PGS, using temporary connections on the valves. Failure of these bottles have no effect on the safety-related function of the MSIVs and MFIVs.

In DCD Tier 2 Section 6.4, "Habitability Systems," the applicant addresses the effect of the PGS on main control room habitability, including explosive gases and burn conditions for those gases. The PGS is designed in conformance with RG 1.91, "Evaluations of Explosions Postulated To Occur on Transportation Routes Near Nuclear Power Plants," for explosions. RG 1.91 provides guidance on acceptable methods to comply with GDC 4 with respect to dynamic effects of explosions of hazardous materials that may be carried near-by transportation routes.

The nitrogen and carbon dioxide portions of the PGS are located inside the turbine building, and the hydrogen system storage is located outdoors at the hydrogen storage tank area. The storage tanks are analyzed as a potential missile source in DCD Tier 2 Section 3.5, "Missile Protection." This is also discussed in Section 3.5.1.1 of this report.

The staff concludes that the PGS is acceptable based on satisfying the guidance of RG 1.91.

9.3.3 Primary Sampling System

The staff reviewed the DCD Tier 2 Section 9.3.3, "Primary Sampling System," in accordance with SRP Section 9.3.2, "Process and Post-Accident Sampling Systems." The primary sampling system (PSS) is acceptable if there are provisions to isolate the system to limit radioactive releases; if the system meets the intended function of collecting and delivering representative samples of fluids from various plant fluid systems to a laboratory for analysis and meets the requirements for seismic design and quality group classification described in the following GDCs:

- GDC 1, as it relates to the design of the components to standards commensurate with the importance of their safety functions, and
- GDC 2, as it relates to the design of the components to withstand the effects of natural phenomena.

GDCs 1 and 2 are met through RG 1.26, "Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste-Containment Components of Nuclear Power Plants," and RG 1.29.

9.3.3.1 Summary of Technical Information

The function of the PSS is to collect liquid and gaseous samples and to provide for local grab samples during normal operation. The system includes provisions to route sample flow to a laboratory for continuous or intermittent sample analysis. The proposed design uses common sampling lines and points. The PSS includes piping, valves, heat exchangers, and other components associated with the system from the point of sample withdrawal from a fluid system up to the analyzing station, sampling station, or local sampling point. The system includes equipment to collect representative samples of various process fluids in a manner that adheres to ALARA principles during normal and post-accident conditions. In addition, the system is designed with a safety-related hydrogen analyzer for monitoring containment atmosphere during a postulated LOCA.

9.3.3.1.1 Process Sampling

During normal plant operations, the PSS collects samples from the reactor coolant system (RCS), the auxiliary primary process system streams, and the containment atmosphere for analysis as specified in DCD Tier 2 Table 9.3.3-1 and Table 9.3.3-2. The results are used to perform the following functions:

- monitor core reactivity,
- monitor fuel rod integrity,
- evaluate ion exchanger (demineralizer) and filter performance,
- specify chemical additions to the various systems,
- maintain acceptable hydrogen levels in the RCS, and
- detect radioactive material leakage.

9.3.3.1.2 Post-Accident Sampling

The PSS does not include specific post-accident sampling capability; however, the design of this system allows for collection and analysis of highly radioactive samples of reactor coolant for boron, containment sump for pH, and containment atmosphere for hydrogen and other fission products.

The requirements for the Post-Accident Sampling System are in 10 CFR 50.34(f)(2)(viii). The reactor coolant and containment atmosphere sampling-line systems should permit personnel to take a sample under accident conditions promptly and with doses less than 5 rem whole body and 50 rem extremity. The radiological spectrum analysis facilities should be capable of quantifying certain radionuclides that are indicators of the degree of core damage promptly. In addition to the radiological analyses, certain chemical analyses are necessary for monitoring reactor conditions.

The NRC published a model Safety Evaluation Report on eliminating the post-accident sampling system requirements from the technical specifications for operating plants (Federal

Register Volume 65, Number 211, October 31, 2000). In DCD Tier 2 Section 1.9.3, Item (2)(viii), the applicant states that the AP1000 sampling design basis is consistent with the approach in the model safety evaluation and not the previous guidance of NUREG-0737, "Clarification of TMI Action Plan Requirements," and RG 1.97, "Instrumentation for Light-Water-Cooled Nuclear Power Plants To Assess Plant and Environs Conditions During and Following an Accident." The guidance of the model Safety Evaluation Report discusses contingency plans to obtain and analyze highly radioactive post-accident samples from the reactor coolant system and the containment sump and the containment atmosphere. The applicant states in DCD Tier 2 Section 1.9.3 that the AP1000 design is consistent with the model Safety Evaluation Report guidance. Therefore, the staff finds the applicant's elimination from TSs of the post accident sampling system for the AP1000 to be acceptable.

9.3.3.2 Staff Evaluation

The intended function of the PSS is to collect and analyze liquid and gaseous samples from the RCS, the auxiliary primary process system streams, and the containment atmosphere. Although the primary sampling system has no safety-related function, some of its sampling lines may be connected to safety-related systems. Therefore, in order to meet the requirements of GDC 1 and 2, the seismic and quality group classification of these lines, associated components, and instruments must conform to the classification of the system to which they are connected. The component classification for the primary sampling system is addressed in DCD Tier 2 Table 3.2-3. The primary sampling system components are classified as ASME Class 2 and 3, seismic Category I. This system meets the quality standards in GDC 1 and the seismic requirements of GDC 2 in that its design conform to the classification of the system to which each sampling line and component is connected in accordance with the regulatory positions in RG 1.26 and RG 1.29.

In addition, the PSS provides for system isolation in the event of an accident to limit radioactive releases through containment isolation valves and purging the sample streams back to the system of origin or the appropriate radwaste system. The design and discussion of the isolation function of this system is found in DCD Tier 2 Section 6.2.3, "Containment Isolation System," and evaluated in the Section 6.2.4 of this report. The staff reviewed and evaluated the design of this system and determined that it includes the components to meet the function and operational requirements of the PSS.

9.3.3.3 Conclusion

The staff's review has determined that the design of the PSS is acceptable because it meets the intended function of sampling liquid and gaseous process streams to monitor plant and various system conditions and there are provisions to isolate the system to limit radiation releases. In addition, the PSS meets the requirements of GDCs 1 and 2 by conforming to RGs 1.26 and 1.29.

9.3.4 Secondary Sampling System

The staff reviewed the DCD Tier 2 Section 9.3.4, "Secondary Sampling System," in accordance with SRP Section 9.3.2, "Process and Post Accident Samplying Systems." The secondary sampling system (SSS) is acceptable if it meets the intended function of collecting and

delivering representative samples of fluids from various plant fluid systems to a laboratory for analysis and GDC 13, "Instrumentation and Control," as it relates to monitoring variables that can affect the fission process, the integrity of the reactor core, and the reactor coolant pressure boundary. The data provided from this system is required for assessing and understanding integrated secondary plant operations.

9.3.4.1 Summary of Technical Information

The function of the SSS is to collect and deliver representative samples of fluids from various plant fluid systems to a laboratory for analysis. The SSS relies on continuous in-line analyses for monitoring the secondary chemistry that is required for assessing and understanding integrated secondary plant operations. It samples water from the turbine cycle, demineralized water treatment, and circulated water systems. The SSS can provide information on the following parameters:

- chloride,
- sulfate,
- silica,
- iron,
- copper content,
- dissolved oxygen,
- pH, and
- conductivity levels.

Grab sample capability is provided as a backup method to obtaining samples, and is also used for calibrating the in-line instrumentation. The steam generator blowdown lines are continuously monitored for radioactivity caused by primary to secondary tube leaks. In case of high radioactivity, this flow path is automatically isolated. This prevents introduction of radioactive fluids into the SSS.

9.3.4.2 Staff Evaluation

The staff review has verified that the secondary sampling system is capable of collecting and delivering for analysis samples of fluids from secondary systems such as the turbine, demineralized water system, and circulating water system. A grab sample capability is provided as a backup. These are non-safety-related functions. In addition, isolation capability is provided to prevent leakage of radioactive fluid from the steam generator boundary. Therefore, the system complies with GDC 13 and the staff finds the AP1000 secondary sampling system to be acceptable.

9.3.4.3 Conclusion

The secondary sampling system instrumentation is capable of monitoring variables and systems over their anticipated range for normal operation, anticipated operational occurences, and for accident conditions as appropriate. This includes both the non-safety-related and the safety-related function of steam generator isolation. Therefore, the secondary sampling system satisfies GDC 13.

9.3.5 Equipment and Floor Drainage System

The staff reviewed the equipment and floor drainage system (EFDS) in accordance with the guidance of SRP Section 9.3.3, "Equipment and Floor Drainage System." Conformance with the acceptance criteria of the SRP forms the basis for concluding whether the EFDS satisfies the following requirements:

- GDC 2, as it relates to the capability of safety-related portions of the system to withstand the effects of earthquakes.
- GDC 4, as it relates to the capability of the system to withstand the effects of flooding and the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents.
- GDC 60, as it relates to providing a means to suitably control the release of radioactive materials in liquid effluent, including during anticipated operational occurrences.

The EFDS consists of the radioactive waste drain system (WRS) and the nonradioactive WWS. These systems collect liquid wastes from equipment and floor drains during normal operation, startup, shutdown, and refueling. The liquid wastes are separated according to the type of waste, and are then transferred to appropriate processing and disposal systems. The WWS is discussed in Section 9.2.9 of this report.

The WRS consists of the following equipment:

- equipment drains
- floor drains
- collection piping
- vents
- traps
- cleanouts
- sampling connections
- valves
- collection sumps
- drain tanks
- sump pumps
- drain tank pumps
- discharge piping

The WRS collects radioactive, borated, chemical, and detergent liquid wastes at atmospheric pressure from equipment and floor drainage of the radioactive portions of the auxiliary building, the annex building, the radwaste building, and the containment building. These radioactive liquid wastes are routed to either the auxiliary building sump, the containment sump, or the reactor coolant drain tank. The contents of the sumps and the drain tank are pumped to the WLS for processing. The WRS system description, components, and flow diagrams are provided in DCD Tier 2 Sections 9.3.5 and 11.2, Tables 9.3.5-1, 11.2-2 and 11.2-4, and Figures 9.3.5-1, 11.2-1 and 11.2-2, respectively.

The auxiliary building consists of a radiologically controlled area (RCA) and a NRCA that are physically separated by structural walls and floor slabs, so that flooding in the RCA will not cause flooding in the NRCA. The drain system in the RCA is completely separated from NRCA drains to prevent cross-contamination of nonradioactive areas. There are no permanent connections between the WRS and nonradioactive piping. However, provisions are included for temporary diversion of contaminated water from normally nonradioactive drains to the WLS. The detection and diversion of radioactive fluids in the nonradioactive WWS is discussed in Section 9.2.9 of this report. Based on the above discussion, the WRS is designed to prevent the inadvertent transfer of contaminated fluids to a noncontaminated drainage system for disposal. On the basis of its review, the staff concludes that the WRS complies with the requirements of GDC 60, with respect to preventing the inadvertent transfer of contaminated fluids to a non-contaminated drainage system for disposal.

As identified in DCD Tier 2 Table 3.2-3, the WRS components are classified as non-safety-related, non-seismic, Quality Group D, with the following exceptions, which are classified as Safety Class 2 or 3, seismic Category I, Quality Group B or C:

- containment isolation valves in the discharge line from the containment sump and the reactor coolant drain tank;
- backflow preventers in the drain lines from containment cavities to the containment sump; and
- drain line piping from the backflow preventers to the containment cavities.

DCD Tier 2 Section 9.3.5.1.1 states that the EFDS is designed to prevent damage to safety-related systems, structures, and equipment. Safety-related components are not damaged as a result of EFDS component failure from a seismic event. Single failures of the EFDS and its equipment will not prevent the proper function of any safety-related equipment. Therefore, the staff concludes that the design presented in the DCD Tier 2 complies with Regulatory Positions C.1 and C.2 of RG 1.29, and that the WRS complies with the requirements of GDC 2, with respect to the capability to withstand the effects of earthquakes.

Operation of the sump pumps and drain tank pumps are not required to mitigate the consequences of design-basis accidents or flooding events. Section 3.4.1 of this report describes the flood protection aspects of the AP1000. Sump pumps inside the containment are interlocked with the associated containment isolation valves. The pumps trip and the isolation valves close on receipt of containment isolation signals to prevent the uncontrollable release of primary coolant outside the containment. Equipment drains are adequately sized to meet the flow requirements. Sump pumps and drain tank pumps discharge at a flow rate adequate to prevent sump overflow for drain rates anticipated during normal plant operation, maintenance, decontamination, fire suppression system testing, and fire fighting activities. Sump and drain tank capacities provide a storage capacity consistent with an operating period of approximately 10 minutes with one pump operating. Plugging of the drain headers is minimized by designing them at least 10.2 cm (4 inches) in diameter, which is large enough to accommodate more than the design flow, and by making the flow path as straight as possible. On the basis of its review, the staff concludes that the WRS complies with the requirements of GDC 4, with respect to the

capability to withstand the effects of flooding and the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents.

On the basis of the above review, the staff concludes that the WRS complies with GDC 2, 4, and 60 as referenced in Section 9.3.3 of the SRP, and is, therefore, acceptable.

9.3.6 Chemical and Volume Control System

The staff reviewed DCD Tier 2 Section 9.3.6, "Chemical and Volume Control System," in accordance with applicable guidance in SRP Section 9.3.4, "Chemical and Volume Control System (PWR) (Including Boron Recovery System)." The SRP indicates that the CVS is acceptable if this system includes components and piping, from the letdown line of the primary system to the charging lines, that provide makeup to the primary system and the reactor coolant pump seal water system, and meets the requirements for system performance of necessary functions during normal, abnormal, and accident conditions described in the following GDCs:

- GDC 1, as it relates to system components being assigned quality group classifications and application of quality standards in accordance with the importance of the safety function to be performed.

- GDC 2, as it relates to structures housing the facility and the system itself being capable of withstanding the effects of earthquakes.

- GDC 5, as it relates to shared systems and components important to safety being capable of performing required safety functions.

- GDC 14, "Reactor Coolant Pressure Boundary," as it relates to assuring RCP boundary material integrity by means of the CVS being capable of maintaining RCS water chemistry.

- GDC 29, "Protection Against Anticipated Operational Occurrences," as it relates to the reliability of the CVS to provide negative reactivity to the reactor by supplying borated water to the RCS in the event of anticipated operational occurrences.

- GDC 33, "Reactor Coolant Makeup," and GDC 35, "Emergency Core Cooling System," as these relate to the CVS capability to supply reactor coolant makeup in the event of small breaks or leaks in the RCPB, to function as part of the emergency core cooling system (ECCS) assuming a single active failure coincident with the loss of offsite power, and to meet ECCS TSs.

- GDC 60 and GDC 61, as these relate to CVS components having provisions for venting and draining through closed systems.

9.3.6.1 Summary of Technical Information

The CVS in the AP1000 design consists of regenerative and letdown heat exchangers, demineralizers and filters, makeup pumps, tanks, and associated valves, piping, and

instrumentation. In addition, the CVS is a non-safety-related system, and its operation is not required to mitigate design-basis events. DCD Tier 2 Section 9.3.6.1.2 describes the following non-safety-related functions performed by the CVS:

- Purification: The CVS removes radioactive corrosion products, ionic fission products, and fission gases from the RCS to maintain low RCS activity levels.

- Reactor coolant system inventory control and makeup: The CVS provides a means to add and remove mass from the reactor coolant system, as required, to maintain the programmed inventory during normal plant operations.

- Chemical shim and chemical control: The CVS provides the means to vary the boron concentration in the RCS and to control the RCS chemistry for limiting corrosion and enhancing core heat transfer.

- Oxygen control: The CVS maintains the proper conditions in the RCS to minimize corrosion of the fuel and primary surfaces; i.e., adding dissolved hydrogen to eliminate free oxygen and to prevent ammonia formation during power operations and introducing an oxygen scavenger at low RCS temperatures during startup from cold shutdown conditions.

- Filling and pressure testing the RCS: The CVS provides a means for filling and pressure testing the RCS.

- Borated makeup: The CVS provides makeup to the passive core cooling system accumulators, core makeup tanks (CMTs), IRWST, and to the spent fuel pool at various boron concentrations.

These safety-related functions connected to the CVS are important to reactor safety.

- containment isolation of the CVS lines penetrating containment,

- termination of inadvertent RCS boron dilution,

- isolation of makeup on an steam generator (SG) or pressurizer high level signal, and

- preservation of the integrity of the RCS pressure boundary, including isolation of normal CVS letdown from the RCS.

9.3.6.2 Staff Evaluation

During an accident, the CVS is not required to provide emergency core cooling or boration. However, the makeup pumps can be used to provide RCS makeup following an accident such as a small LOCA and can furnish pressurizer auxiliary spray to reduce RCS pressure for certain accident scenarios, thereby improving the reliability of the plant.

DCD Tier 2 Section 9.3.6.2, "System Description," describes that the CVS design consists of regenerative and letdown heat exchangers; demineralizers and filters; makeup pumps, tanks,

and associated valves, piping and instrumentation. The CVS purification loop is located entirely inside the containment, and operates at RCS pressure in a closed loop without the CVS makeup pumps, using the developed head of the reactor coolant pumps as a motive force for the purification flow. The primary coolant passes through the regenerative and letdown heat exchangers, where it is cooled to the temperature compatible with the resin in the demineralizer. The coolant then passes through one of the two demineralizers containing mixed bed resin.

After passing through the demineralizers, the coolant is directed through the secondary side of the regenerative heat exchanger back to the primary loop. During plant shutdown, when the pumps are not operating, the normal RHR system provides the motive force for the purification loop.

The CVS has enough capacity to accommodate minor leakage from the RCS, and provides inventory control during plant heatups and cooldowns. In addition to controlling coolant inventory in the primary coolant system, the CVS is used to provide borated water for passive core cooling system accumulators, CMTs, and the SFP. It is also used for filling and pressure testing of the RCS after maintenance and refueling.

Control of pH is achieved through injecting lithium hydroxide from the chemical mixing tank into the makeup water. Since the CVS is a non-safety-related system, its operation is not required to mitigate the design basis events. Therefore, the CVS is not required to meet the safety-related system requirements. However, the CVS provides the first line of defense during an accident to prevent unnecessary actuation of passive core cooling systems.

The staff reviewed the design of the CVS and its ability to maintain the required water inventory and quality in the RCS, provide seal-water flow to the RCPs and pressurizer auxiliary spray, control the boron neutron absorber concentration in the RCS, and control the primary water chemistry and reduce coolant radioactivity level. In addition, the staff reviewed the design of this system in providing recycled coolant for demineralized water makeup for normal operation and its capability to provide high pressure injection flow to the ECCS in the event of postulated accidents.

The staff also noted the discussion in DCD Tier 2 Section 9.3.6.5, "Design Evaluation" which addresses the basis for the CVS design. The specific GDCs applicable to this system; i.e., GDCs 1, 2, 5, 14, 29, 33, 35, 60 and 61, are discussed in DCD Tier 2 Section 3.1, "Conformance with Nuclear Regulatory Commission General Design Criteria." In addition, DCD Tier 2 Section 1.9, "Compliance with Regulatory Criteria," discusses compliance with RG 1.26 and RG 1.29.

Based on the information provided in these sections, the staff determined that the CVS meets the following:

- GDC 1 and RG 1.26 by assigning quality group classifications to system components in accordance with the importance of safety function to be performed;

- GDC 2 and RG 1.29 by designing safety-related portions of the system to seismic Category I requirements;

- GDC 5 by designing AP1000 as a single-unit plant and additional units on the same site will not have shared safety-related systems;

- GDC 14 by providing the necessary components to maintain reactor coolant purity and material compatibility to reduce corrosion;

- GDC 29 by including the necessary components to provide negative reactivity through injection of borated water into the RCS;

- GDCs 60 and 61 by designing this system to be capable of confining radioactivity by venting and collecting drainage through closed systems.

- GDCs 33 and 35 are satisfied by passive systems. However, non-safety-related portions of the CVS are designed with the capability to provide borated makeup to the RCS following accidents such as small LOCAs, steam generator tube rupture events and small steam line breaks.

9.3.6.3 Conclusion

DCD Tier 2 Section 9.3.6.5 provides a summary of the compliance of the CVS with regulatory requirements and guidance. The applicant indicates that the design of the CVS is based on specific GDC and RGs specified in SRP Section 9.3.4. The specific GDCs identified in the SRP are GDC 1, 2, 5, 14, 29, 33, 35, 60, and 61. Although the AP1000 CVS is not a safety-related system and its design need not strictly adhere to the criteria listed in the SRP, the applicant compared the AP1000 CVS design to the requirements of the GDCs and concluded that it meets these requirements, which were discussed for the AP1000 in DCD Tier 2 Section 3.1. The staff agrees with this conclusion.

In addition, the staff concludes that the design of the CVS includes the components and piping to provide inventory control and chemically controlled makeup to the primary system and the reactor coolant pump seal water system. Also, the CVS includes components to isolate containment and preserve the integrity of the RCPB. Therefore, the staff concludes that the CVS meets the intent of GDC 1, 2, 5, 14, 29, 33, 35, 60, and 61, and is therefore acceptable.

9.4 Air-Conditioning, Heating, Cooling, and Ventilation System

In DCD Tier 2 Section 3.1.1, the applicant states that the AP1000 design is a single-unit plant; if more than one unit is built on the same site, none of the safety-related systems will be shared. Thus, independence of all safety-related systems and their support systems will be maintained among the individual plants. The staff determined that the HVAC systems design described in the DCD do not share SSCs with other nuclear power units. Therefore, the HVAC cooling systems meet the requirements of GDC 5. DCD Tier 2 Table 9.4-1 lists the standards to which the various components of the HVAC systems are designed.

The staff's review of the AP1000 air-conditioning, heating, cooling, and ventilation systems is provided in the following Sections: 9.4.1, "Nuclear Island Nonradioactive Ventilation System"; 9.4.2, "Annex/Auxiliary Buildings Non-Radioactive HVAC System"; 9.4.3, "Radiologically Controlled Area Ventilation System"; 9.4.4, "Balance-of-Plant-Interfaces"; 9.4.5, "Engineered

Safety Features Ventilation System"; 9.4.6, "Containment Recirculation Cooling System"; 9.4.7, "Containment Air Filtration System"; 9.4.8, "Radwaste Building HVAC System"; 9.4.9, "Turbine Building Ventilation System"; 9.4.10, "Diesel Generator Building Heating and Ventilation System"; and 9.4.11, "Health Physics and Hot Machine Shop HVAC System".

The relevant codes and standards for the design, maintenance, and testing of air-conditioning, heating, cooling, and ventilation systems are listed in Table 9.4-1 of this report.

The NRC staff stated, as part of its requested additional information in RAI 410.009, that the AP1000 design should comply with the latest revisions of the applicable Codes and Standards for the following HVAC systems:

- radiologically controlled area ventilation system (VAS),
- non-radioactive ventilation system (VBS),
- containment recirculating cooling system (VCS),
- main control room emergency habitability system (VES),
- containment air filtration system (VFS),
- health physics and hot machine shop HVAC system (VHS),
- radwaste building HVAC system (VRS),
- turbine building ventilation system (VTS),
- annex/auxiliary buildings non-radioactive HVAC system (VXS), and
- diesel generator building heating and ventilation system (VZS)

The RAI also requested that the applicant should revise the DCD, as necessary. In a letter dated February 14, 2003, the applicant provided additional information that revised their original response to RAIs 410.007 and 410.009 asserting that the AP1000 HVAC design meets the codes and standards and issue date as identified in the DCD Tier 2 Section 9.4.13, "References," and these codes and standards are up to date as of the submittal date of the DCD to the NRC. The applicant provided further assurance that the use of these codes and standards will result in a technically suitable HVAC design for the AP1000. The NRC staff expects that a future DCD revision will include the codes and standards (including NRC guidance documents) that are in effect as of the submittal date of the DCD Tier 2 (March 28, 2002) and that references identified in DCD Tier 2 Sections 6.4.8, 9.4.13, and Appendix 1A will be updated accordingly. In a letter dated May 21, 2003, the applicant provided a response to RAI 410.007. However, there was insufficient time for the staff to review this response. Therefore, this is Open Item 9.4-1.

9.4.1 Nuclear Island Non-radioactive Ventilation System

The staff reviewed the VBS in accordance with SRP Section 9.4.1, "Control Room Area Ventilation System." Conformance with the SRP acceptance criteria forms the basis for concluding whether the VBS satisfies the following requirements:

- GDC 2, regarding the capability to withstand earthquakes.

- GDC 4, regarding maintaining environmental conditions in essential areas compatible with the design limits of the essential equipment located therein during normal, transient, and accident conditions.

- GDC 5, regarding sharing systems and components important to safety.

- GDC 19, "Control Room," regarding maintaining the control room in a safe, habitable condition under accident conditions by providing adequate protection against radiation and toxic gases.

- GDC 60, regarding the capability to suitably control release of gaseous radioactive effluent to the environment.

The VBS provides safety-related design basis functions to (1) monitor air supply for radioactive particulate and iodine concentrations inside the main control room envelope (MCRE), and (2) isolate the safety-related, seismic Category I HVAC piping penetrating the MCRE based upon "high-high" particulate or iodine radioactivity detection in the supplied air or on extended loss of ac power to support operation of the main control room emergency habitability system as described in Section 6.4 of this report. The system is designed to maintain proper environmental conditions and control of contaminant levels. The VBS maintains the main control room (MCR) and technical support center (TSC) carbon dioxide levels below 0.5 percent concentration and the air quality within the guidelines of Table 1 and Appendix C, Table C-1 of American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 62-1999, "Ventilation for Acceptable Indoor Air Quality." The applicant states that the VBS is non-safety-related; however, if the system is operational and ac power is available, the system provides for habitability inside the MCRE (within the guideline of SRP Section 6.4, "Control Room Habitability System," and the TSC (within the guideline of NUREG-0696, "Functional Criteria for Emergency Response Facilities").

The VBS can provide habitability because it is designed, constructed, and tested to conform with Generic Safety Issue (GSI) B-36, "Develop, Design, Testing, and Maintenance Criteria for Atmosphere Cleanup System Air Filtration and Adsorption Units for Engineered Safety Features Systems and for Normal Ventilation Systems;" GSI B-66, "Control Room Infiltration Measurements;" RG 1.140, Revision 2, "Design, Inspection and Testing Criteria for Air Filtration and Adsorption Units of Normal Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants," as discussed in DCD Tier 2 Chapter 1.0, Appendix 1A, and American Society of Mechanical Engineers (ASME) N510-1989, "Testing of Nuclear Air-Treatment Systems." GSI B-36 is discussed in Chapter 20 of this report.

In addition, the applicant stated in DCD Tier 2 Section 9.4.12, "Combined License Information," that COL applicants referencing the AP1000 design will implement a program to maintain compliance with ASME/ANSI AG-1-1997, "Code on Nuclear Air and Gas Treatment," and Addenda AG-1a-2000, "Housings;" ASME N509-1989, "Nuclear Power Plant Air-Cleaning Units and Components;" ASME N510-1989; and RG 1.140, Revision 2, for portions of the VBS and VFS identified in DCD Tier 2 Sections 9.4.1 and 9.4.7. The staff finds this acceptable because the applicant is referring to industry codes and standards that are specified in RG 1.140, Revision 2. This is COL Action Item 9.4.1-1.

For the post 72-hour design basis accident, the specific function of the VBS is to maintain the MCR below a temperature approximately 2.5 °C (4.5 °F) above the average outdoor temperature. In addition, the VBS is designed to maintain the instrumentation and control (I&C) rooms (Divisions B & C) below the qualification temperature of the I&C equipment (49 °C (120

°F)) for the post 72-hour design basis accident. The ancillary fans are intended to meet the above post 72-hours ventilation criteria for the MCR and Class 1E I&C rooms. The staff's evaluation of the post 72-hours power supply is discussed in Section 8.3 of this report.

The VBS consists of the following subsystems:

- The MCR/TSC HVAC subsystem serves the MCR and the TSC.

- The Class 1E electrical room HVAC subsystem serves the Class 1E dc equipment rooms, electrical penetration rooms, battery rooms, and I&C rooms, remote shutdown area, reactor cooling pump trip switchgear rooms, and adjacent corridors.

- The PCS valve room heating and ventilating subsystem serves the PCS valve room.

Descriptions, design parameters, instrumentation (including indications and alarms), and figures for the VBS and the interfacing VES are provided in DCD Tier 2 Sections 6.4, 9.4.1, and 15.6.5.3; Tables 3.2-1, 6.4-1 through 6.4-3, 9.4.1-1, and 15.6.5-2; and Figures 1.2-8, 6.4-1, 6.4-2, and 9.4.1-1, respectively. Instrumentation for the VES and VBS are discussed in DCD Tier 2 Section 7.3, "Engineered Safety Features." Details of radiation monitors, including testing and inspection, are provided in DCD Tier 2 Section 11.5, "Gaseous Waste Management System." The staff's evaluation of the chilled water system is discussed in Section 9.2.7 of this report. The staff's evaluation of fire protection is discussed in Section 9.5.1 of this report. Table 9.4-1 of this report describes the industry standards applicable to the HVAC system, including components of the VBS.

The MCRE penetrations include isolation valves, interconnecting piping, and vent and test connections with manual valves that are classified a safety Class C and seismic Category I. The MCRE isolation valves have electro-hydraulic operators and are designed to fail closed during a LOOP event. The safety-related isolation valves are included in the technical specifications for periodic testing and are also included in the inservice testing (IST) program.

The MCR/TSC HVAC subsystem filtration unit configurations, including housing, internal components, ductwork, dampers, fans and controls, and the location of the fans on the filtered side of units are designed, constructed, and tested in accordance with ASME N509-1989, ASME N510-1989, and RG 1.140, Revision 2. The ductwork for the supplemental air filtration subsystem and portions of the MCR/TSC HVAC subsystem that maintains the integrity of the MCR/TSC pressure boundary, during conditions of abnormal airborne radioactivity, is tested for leak tightness in accordance with ASME N510-1989.

The remaining supply and return/exhaust ductwork is tested in place for leakage in accordance with Sheet Metal and Air-conditioning National Association (SMACNA), 1985, "HVAC Duct Leakage Test Manual." The high-efficiency particulate air (HEPA) filters are shop tested to verify an efficiency of at least 99.97 percent using a monodisperse 0.3-µm aerosol and constructed, qualified, and tested in accordance with ASME N509-1989 and Underwriters Laboratory (UL)-586, 1996, "High-Efficiency, Particular, Air-Filter Units." Post filters downstream of the charcoal adsorbers have a minimum dioctyl-phthalate polydispersed (DOP) test efficiency of 95 percent. Each charcoal adsorber is a single assembly with welded construction and 100 mm (4 in) deep type III rechargeable adsorber cell. The charcoal

adsorbers conform with NRC Inspection and Enforcement (IE) Bulletin 80-03, "Loss of Charcoal from Adsorber Cells," and are qualified, constructed, and tested in accordance with ASME/ANSI AG-1-1997 and Addenda AG-1a-2000, ASME N509-1989, ASME N510-1989, and RG 1.140, Revision 2. A representative charcoal sample, used or new, is laboratory tested to verify a minimum charcoal efficiency of 90 percent in accordance with RG 1.140, Revision 2, and conforming to ASME N510-1989 for test procedures and test frequency.

The system ductwork flow is tested, balanced and adjusted in accordance with SMACNA, 1993, "Testing, Adjusting, and Balancing." Fire dampers or combination fire/smoke dampers are provided at duct penetrations through fire barriers to maintain the fire resistance ratings of the barriers. The MCR/TSC HVAC and Class 1E electrical room HVAC subsystems are designed so that smoke, hot gases, and fire suppressant does not migrate from one fire area to another to the extent that they could adversely affect the safe shutdown capabilities, including operator actions. Fire or combination fire and smoke dampers are provided for MCRE areas, Class 1E equipment rooms, and the remote shutdown workstation room to isolate each fire area from adjacent fire areas during and following a fire in accordance with the National Fire Protection Association (NFPA) 90A-1999, "Installation of Air Conditioning and Ventilation Systems."

If the VBS is not available during the 72-hour period following the onset of a postulated design-basis accident, the VES provides passive heat sinks to limit the temperature rise in the MCRE, I&C rooms, and dc equipment rooms. The heat sinks consist primarily of the thermal mass of the concrete that makes up the ceilings and walls of these rooms. As described in DCD Tier 2 Section 6.4.2.2, to enhance the heat absorbing capacity of the ceilings, a metal form is attached to the surface of the concrete at selected locations. Metallic plates are attached perpendicularly to the ceiling metal form. These plates extend into the room and act as thermal fins to enhance the heat transfer from the room air to the concrete. The VBS cooling and heating capacity is dependent on the site interface parameters for maximum and minimum normal temperature conditions, as defined in DCD Tier 2 Chapter 2, Table 2-1, and summarized as follows:

- The MCR/TSC HVAC subsystem maintains the MCR and TSC between 19.4 to 23.9 °C (67 to 75 °F) and 25 percent to 60 percent relative humidity (RH). The VBS maintains the VES passive cooling heat sink below its initial design ambient air temperature limit of 23.9 °C (75 °F).

- The Class 1E electrical room HVAC subsystem maintains the Class 1E dc equipment rooms between 19.4 to 23.9 °C (67 to 75 °F); Class 1E electrical penetration rooms, Class 1E battery rooms, Class 1E instrumentation and control rooms, remote shutdown area, reactor cooling pump trip switchgear rooms, and adjacent corridors between 19.4 to 22.8 °C (67 to 73 °F); and HVAC equipment rooms between 10 to 29.4 °C (50 to 85 °F).

- The VBS maintains the Class 1E electrical room emergency passive cooling heat sink below its initial design ambient air temperature limit of 23.9 °C (75 °F).

- The VBS vents the Class 1 battery rooms to limit the hydrogen gas concentration to less than 2 percent by volume.

- The PCS valve room heating and ventilation subsystem maintains the PCS valve room at 10 °C to 48.9 °C (50 to 120 °F).

The single outside air intake serving the VBS conforms with the guidance of Section 6.4 of the SRP and RG 1.78, Revision 1, "Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release." Outside supply air is provided to the plant by the MCR/TSC HVAC subsystem through an outside air intake that is protected by an intake enclosure located on the roof of the auxiliary building at Elevation 153'-0". As stated in DCD Tier 2 Section 6.4.4, the fresh air intake of the MCR is located in excess of 45.7 m (150 ft) from the flue gas exhaust stacks of the onsite standby power diesel generators, and 91.4 m (300 ft) from the onsite standby power system fuel oil storage tanks. This location precludes the combustion fumes or smoke from an oil fire from being drawn into the MCR. It is located more than 15.2 m (50 ft) below and more than 30.5 m (100 ft) laterally away from the plant vent discharge. The split-wing type tornado protection dampers close automatically and can withstand the effects of 134 m/s (300 mph) wind.

As shown in DCD Tier 2 Figure 9.4.1-1, the fresh air supply from an air intake is automatically isolatable by a fail-closed, electro-hydraulically operated isolation damper at the inlet of each air filtration train. Normally, one VBS air filtration unit train isolation damper is opened, and the other air filtration unit train isolation damper is closed. There are two fail-closed isolation dampers in series in the common outside air supply to each of the normal air handling units. The radiation monitors and outside air isolation dampers are shown on DCD Tier 2 Figure 9.4.1-1. The outside air is continuously monitored by redundant smoke monitors at the outside air intake. Redundant safety-related radiation monitors are located in the MCRE upstream of the supply air isolation valves. As described in DCD Tier 2 Section 9.4.1.2.3.1, these monitors initiate operation of the non-safety-related supplemental air filtration units on "high" gaseous radioactivity concentrations and isolate the MCR from the VBS on "high-high" particulate or iodine radioactivity concentrations.

In DCD Tier 2 Section 9.4.12, the applicant states that the COL applicant will provide a description of the MCR/TSC HVAC subsystem’s recirculation mode during emergencies involving toxic substances, and how the subsystem equipment isolates and operates, as applicable, consistent with the issues regarding toxic substances to be addressed by the COL applicant, as discussed in DCD Tier 2 Section 6.4.7. This is COL Action Item 6.4.7-1, as discussed in Section 6.4.7 of this report.

Portions of the VBS that provide the defense-in-depth (DID) function of filtration of MCR/TSC air during conditions of abnormal airborne radioactivity are designed, constructed, and tested to conform with GSI B-36, GSI B-66, RG 1.140, and ASME N509 and N510 standards. System redundancy for the MCR/TSC HVAC subsystem is provided and the system is automatically transferred to the onsite non-safety-related diesel generators on LOOP. The equipment is located in separate fire areas and high in the building to protect it from flooding. The system quality assurance, availability, and administrative controls are addressed in DCD Tier 2 Chapters 17, 16, and 13. The VBS is located in the auxiliary building and equipment will be procured to manufacturer’s standards, and as with the other equipment of the nuclear island, it is protected from defined natural phenomena.

The VBS is controlled by the plant control system, except for the MCRE isolation valves, which are controlled by the protection and safety monitoring system. The plant control and plant safety and monitoring systems are discussed in Section 7.1.1 of this report. The instrumentation to satisfy Table 4-2 of ASME N509-1989 is discussed in DCD Tier 2 Section 9.4.1.5 for the DID VBS supplemental air filtration units. Radioactivity indication and alarms are provided to inform the MCR operators of gaseous, particulate, and iodine radioactivity concentrations in the MCR supply air duct. In DCD Tier 2 Section 11.5, the applicant provides the description of the MCR supply air duct radiation monitors and their actuation functions. Smoke monitors are provided to detect smoke in the outside air intake duct to the MCR and the MCR and Class 1E electrical room return air ducts. Temperature indications and alarms are provided in the return air ducts to control the room air temperatures within the predetermined range. Temperature indications and alarms for the MCR return air, Class 1E electrical return room air, air handling unit (AHU) supply air, supplemental filtration unit prefilter inlet air, and charcoal adsorbers are provided to inform plant operators of abnormal temperature conditions. Pressure differential indications and alarms are provided to control the MCR and monitor the TSC ambient pressure differentials with respect to the surrounding areas. Airflow indication and alarms are provided to monitor operation of the supply and exhaust fans.

9.4.1.1 Main Control Room/Technical Support Center HVAC Subsystem

The MCR/TSC subsystem serves: (1) the MCRE as shown in DCD Tier 2 Figure 6.4-1, which consists of the main control area, shift supervisor office, tagging room, toilet (area), clerk room, kitchen/ operator area, hallway and double door vestibule; and (2) the TSC areas consisting of the main TSC operating area, conference rooms, NRC room, computer rooms, shift turnover room, kitchen/rest area, and rest rooms. The MCR and TSC toilets each have a separate exhaust fan.

The MCR/TSC subsystem consists of redundant 100-percent capacity supply AHUs, supplemental air filtration units, return/exhaust air fans, associated dampers, instrumentation and controls, and common ducts for the MCR and TSC. Each supply AHU consists of a mixing box section, supply air fan, a low-efficiency filter bank, a high-efficiency filter bank, an electric heating coil, chilled water cooling coil bank, and a humidifier. The supply of the chilled water is normally provided from air-cooled chillers in the VWS.

The supply AHUs and return/exhaust air fans are connected to a common duct that distributes air to the MCR/TSC HVAC subsystem. The only HVAC penetrations in the MCRE are MCR supply, return, and toilet exhaust ducts. These penetrations include redundant safety-related seismic Category I isolation valves that are physically located in the MCR envelope. The isolation valves isolate the non-safety-related portions of the subsystem from the MCRE when the VES is operating.

The normal outside makeup air is provided to the subsystem through an outside air intake duct that is protected by a non-seismic Category I intake enclosure. The applicant states that the non-seismic Category I enclosure is acceptable because failure of the VBS air intake enclosure will not affect the safety-related operation of the VES, including the initial pressure assumptions required by the VES to maintain the control room habitability during a design-basis LOCA. The outside supply air intake enclosure for the MCR/TSC HVAC subsystem is shared by the A and

C Class 1E electrical room HVAC subsystem. The staff agrees with the applicant's justification for a non seismic Category I intake enclosure.

The tempered air through each AHU is controlled by temperature sensors located in the MCR return air duct to maintain the ambient air design temperature within its normal design temperature range by modulating electric heating or chilled water cooling coil.

Each supplemental air filtration unit includes a high-efficiency filter bank, an electric heating coil, charcoal adsorber with an upstream and downstream HEPA filter bank and a fan. Both redundant trains of the supplemental filtration units and one train of the supply AHU are located in the MCR mechanical equipment room at Elevation 135'-3" of the auxiliary building. The other supply AHU is located in the MCR mechanical equipment room at Elevation 135'-3" of the annex building. The MCR toilet exhaust fan is located at Elevation 135'-3" of the auxiliary building. The filtration unit's housings are located outside the MCRE, designed to meet the performance requirements of ASME/ANSI AG-1-1997 and Addenda AG-1a-2000, ASME N509 and N510 standards, and operated at a negative pressure.

In DCD Tier 2 Table 9.4.1-1, the applicant shows that the depth of the activated charcoal adsorber is 102 mm (4 inches) with an adsorber efficiency of 90 percent, and a HEPA filter efficiency of 99 percent. In addition, DCD Tier 2 Table 9.4.1-1 shows a maximum MCRE in-leakage of 0.0658 m^3/sec (140 scfm) [including in-leakages of 0.0047 m^3/sec (10 scfm) through MCR access doors, 0.0047 m^3/sec (10 scfm) through TSC access doors, and 0564 m^3/sec (120 scfm) through MCR/TSC HVAC equipment and ductwork (operating)]. The MCR/TSC HVAC equipment ductwork, that forms an extension of the MCR/TSC pressure boundary, limits the overall infiltration (negative operating pressure) and exfiltration (positive operating pressure) rates to those values shown in DCD Tier 2 Table 9.4.1-1 to maintain operator doses within the allowable GDC 19 limits, as applied to the AP1000 design.

During normal operation, one of the two 100-percent capacity supply AHUs and supply/exhaust air fans operate continuously. Outside makeup air to supply AHUs is provided through an air intake duct. The outside air flow rate is automatically controlled to maintain the MCR/TSC areas at a slightly positive pressure with respect to the surrounding areas and outside environment. The standby AHU and its corresponding return/exhaust fans start automatically if (1) the operating fan air flow drops below predetermined setpoints, (2) return air temperature is above or drops below predetermined setpoints, (3) differential pressure between the MCR and the surrounding areas and outside environment is above or below predetermined setpoints, or (4) electrical and/or control power to the operating unit is lost.

The applicant described the design and operation of the MCR/TSC HVAC subsystem in DCD Tier 2 Section 9.4.1.2.3.1. During abnormal plant operation with high gaseous radioactivity detected in the MCR supply air duct, the system is designed to maintain control room operator doses within the dose acceptance criteria of GDC 19, as applied to the AP1000 design. When high gaseous radioactivity is detected in the MCR supply air duct and the MCR/TSC HVAC subsystem is operable, both supplemental air filtration units automatically start to pressurize the MCR/TSC areas to at least 0.03 kPa (1/8" water gauge) using filtered makeup. One of the supplemental filtration units is then manually shutdown. The normal outside air makeup duct and the MCR and TSC toilet exhaust duct isolation valves close. The smoke/purge isolation dampers close, if open. The subsystem AHU continues to provide cooling, in the recirculation

mode, by maintaining the MCRE passive heat sink below its initial ambient air design temperature and maintaining the MCR/TSC areas within their design temperature. The supplemental filtration pressurizes the combined volume of the MCR and TSC concurrently with filtered air. A portion of the recirculated air (approximately, 4,000 cfm) from the MCR and TSC is also filtered for cleanup of airborne radioactivity.

During abnormal operation, if ac power is unavailable for more than ten minutes or "high-high" particulate or iodine radioactivity is detected in the MCR supply air duct (which would lead to exceeding operator dose limits of GDC 19 as applied to the AP1000 design) the plant safety monitoring system automatically isolates the MCRE from the normal MCR/TSC HVAC subsystem by closing the supply, return, and toilet exhaust isolation valves. The VES safety-related supply isolation valve in each train opens automatically to protect the MCR occupants from a potential radiation release, because the radiation monitors are effective only when there is air flow through the VBS ductwork. Section 6.4 of this report discusses the emergency mode of operation.

The MCR/TSC subsystem complies with GDC 60, as it relates to protecting those who access the control room during accidental radioactive releases, by initiating the supplemental filtration subsystem. The MCR/TSC subsystem conforms with RG 1.140, Revision 2, regarding detection of high radioactivity or isolating the MCRE and initiating the VES on detection of high-high airborne radioactivity through the redundant nuclear safety-related radiation monitors. The MCR and TSC areas ventilation supply and return/exhaust air ducts can be manually isolated from the MCR.

If a high concentration of smoke is detected in the outside air intake, an alarm is initiated in the MCR. The MCR/TSC subsystem is then manually realigned to the recirculation mode by closing the outside air and toilet exhaust duct isolation dampers. The MCR and TSC toilet/kitchen exhaust fans are tripped upon closure of the isolation valves. During the recirculation mode, the MCR/TSC areas are not pressurized. The MCR/TSC subsystem continues to provide cooling and ventilation to maintain the emergency passive heat sink below its initial ambient air design temperature and maintains the MCR/TSC areas within their design temperature.

In the event of a fire in the MCR/TSC, the fire/smoke dampers close automatically to isolate the fire area, while the unaffected areas are maintained at a slight positive pressure by the MCR/TSC subsystem. The MCR/TSC subsystem continues to provide ventilation and cooling to the unaffected areas and maintain them at a slight positive pressure. The MCR/TSC subsystem can be realigned manually to the once-through ventilation mode to supply 100 percent outside air to the unaffected areas.

Power is supplied to the subsystem by the plant ac electrical system. In the event of a LOOP when the plant ac electrical system is unavailable, the subsystem is automatically transferred to the onsite standby diesel generators.

In the event that complete ac power is lost and the outside air is acceptable (on the basis of compliance with the requirements of GDC 19), MCRE habitability is maintained by operating one of the two MCR ancillary fans to supply outside air to the MCRE. The outside air supply pathways to the ancillary fans and warm air vent pathways are described in DCD Tier 2

Section 9.4.1.2.3.1. Power to the ancillary fans is from the respective division B or C regulating transformers, which receive power from the ancillary diesel generators. The ancillary fans' flow paths are located within the auxiliary building, which is a seismic Category I structure. Once the normal ventilation is restored, the ancillary fan circuits are disabled manually. The applicant states that the ancillary fans are centrifugal type with non-overloading horse power characteristics; conform to ANSI/AMCA 210, 211, and 300 standards; and each fan can provide a minimum of 1530 cfm. The capacity and air flow rate maintain the MCRE environment near the daily average outdoor air temperature. As discussed in Section 22.5.4.3 of this report, short-term administrative controls are provided for the MCR ancillary fans as part of the regulatory treatment of non-safety systems (RTNSS) process.

9.4.1.2 Class 1E Electrical Room HVAC Subsystem

The Class 1E electrical room (ER) HVAC subsystem has two ventilation trains. One train serves the A and C electrical divisions, spare battery rooms (non-Class 1E), Class 1E spare battery rooms, and reactor pump trip switchgear rooms, and the other train serves the B and D electrical divisions and the remote shutdown work station area.

Each subsystem consists of two 100-percent capacity AHUs, return/smoke exhaust air fans, associated dampers, instrumentation and controls, and common ductwork. The AHUs and return/exhaust fans are connected to a common duct that distributes supply air to the Class 1E electrical rooms. Each supply AHU consists of a mixing box section, supply air fan, a low-efficiency filter bank, a high-efficiency filter bank, an electric heating coil, and chilled water cooling coil bank. The supply of the chilled water is normally provided from air-cooled chillers in the VWS. Additionally, the Class 1E battery rooms are provided with duct-mounted electric heating coils and two 100-percent capacity exhaust fans. The HVAC equipment serving the A and C electrical divisions is located in the MCR A and C equipment rooms at Elevation 135'-3" of the auxiliary building. The HVAC equipment serving the B and D electrical divisions is located in the upper and lower B and D equipment rooms at Elevation 117'-0" and Elevation 135'-3" of the auxiliary building.

During normal operation, one of the redundant supply AHUs, return fans, and battery room exhaust fans operate continuously to maintain acceptable environmental conditions, maintain the Class 1E electrical room emergency passive heat sink below its initial ambient air temperature, and prevent hydrogen gas buildup in the Class 1E battery rooms. The battery exhaust is vented directly to the turbine building vent to limit the hydrogen gas concentration to less than 2 percent by volume in accordance with RG 1.128, Revision 1, "Installation Design and Installation of Large Lead Storage Batteries for Nuclear Power Plants."

The normal outside makeup air is provided to the subsystem through an outside air intake duct that is protected by an intake enclosure. The outside supply air intake enclosure for the A and C Class 1E ER HVAC subsystem is common for the MCR/TSC HVAC subsystem air intake located on the roof of the auxiliary building at Elevation 153'-0". The outside supply air intake for the B and D Class 1E ER HVAC subsystem is located and separated from the MCR/TSC HVAC subsystem air intake enclosure on the roof of the auxiliary building at Elevation 153'-0".

The tempered air through each AHU is controlled by temperature sensors located in the return air duct. The tempered air maintains the room air temperature within the normal design range

by modulating electric heating or the chilled water cooling coil. The standby supply AHU, and corresponding return/smoke exhaust fans, are started automatically if the operating fan air flow drops below a predetermined set point, the return air temperature is above or drops below predetermined setpoints, or the electrical and/or control power is lost to the operating unit.

The operation of the Class 1E ER HVAC subsystem is not affected by abnormal events resulting in detection of airborne radioactivity in the MCR supply air duct of the MCR/TSC HVAC subsystem. During a design-basis accident (DBA), if both onsite and offsite power are lost, the Class 1E electrical room emergency passive heat sink will provide area temperature control, as discussed in Section 6.4 of this report.

If a high concentration of smoke is detected in the air intake, an alarm is initiated in the MCR. The Class 1E ER HVAC subsystem is then manually realigned to the recirculation mode of operation by closing the outside air intake damper to the AHU mixing plenum, allowing 100 percent room air to return to the supply air subsystem AHU. During the recirculation mode of operation, the subsystem continues to maintain the served areas within their air design temperatures and pressures.

In the event of a fire in a Class 1E electrical room, fire/smoke dampers close automatically to isolate the fire area and the unaffected areas are maintained at a slight positive pressure by the subsystem. One or both trains of the subsystem can be manually realigned to the once-through ventilation mode to provide 100 percent outside air to the unaffected areas.

Realignment to the once-through ventilation mode minimizes the potential for migration of smoke and hot gases from a non-Class 1E electrical room (or a non-Class 1E electrical room of one division into the Class 1E electrical room of another division). Smoke and hot gases can be removed from the affected areas by reopening the closed combination fire/smoke dampers from outside of the affected fire area during the once-through ventilation mode. In the once-through ventilation mode, the outside air intake damper (to the AHU mixing plenum) opens and the return air damper (to the supply AHU) closes to allow 100 percent outside air to the supply AHU. The subsystem exhaust air isolation damper also opens to exhaust room air directly to the turbine building vent.

Power is supplied to the subsystem by the plant ac electrical system. In the event of a LOOP and the plant’s ac electrical system is unavailable, the subsystem is automatically transferred to the onsite standby diesel generators.

When complete ac power is lost, division B and C I&C room temperature is maintained by operating their respective MCR ancillary fans to supply outside air to the I&C rooms. The outside air supply pathways to the ancillary fans and warm air vent pathways are described in DCD Tier 2 Section 9.4.1.2.3.2. Power supply to the ancillary fans is from the respective division B or C regulating transformers, which receive power from the ancillary diesel generators. The ancillary fans flow path are located within the auxiliary building, which is a seismic Category I structure. Once the normal ventilation is restored, the ancillary fan circuits are disabled manually. As discussed in Section 22.5.4.3 of this report, short-term administrative controls are provided for the MCR ancillary fans as part of the RTNSS process.

9.4.1.3 Passive Containment Cooling System Valve Room Heating and Ventilating Subsystem

The PCS valve room heating and ventilation subsystem consists of one 100-percent capacity exhaust fan, two 100-percent capacity electric unit heaters, and associated dampers, instrumentation, and controls. The subsystem equipment is located in the PCS valve room in the containment dome area at Elevation 286'-6".

During normal operation, the exhaust fan draws outside air through an intake louver damper and directly exhausts it to the environment to maintain room temperature within its normal design temperature range. The lead electric unit heater starts or stops when the room air temperature is above or drops below predetermined setpoints. The standby electric unit heater starts automatically if the airflow temperature of the operating electric unit heater drops below a predetermined setpoint.

The exhaust fan and electric heaters are powered by the plant ac electrical system and, in the event of a LOOP, the power source is automatically transferred to the onsite standby diesel generators for the electric unit heaters. Following a fire in the PCS valve room, smoke and hot gases can be removed from the area using portable exhaust fans and flexible ductwork.

9.4.1.4 Conclusion

The VBS is located inside seismic Category I (auxiliary building) and seismic Category II (annex building) buildings, which provide flood and tornado-missile protection. The safety-related MCR isolation dampers are seismic Category I, as shown in DCD Tier 2 Table 3.2-1. Therefore, the system's safety-related portions comply with the guidelines of Regulatory Position C.1 of RG 1.29. The system's non-safety-related portions comply with Regulatory Position C.2 of RG 1.29, because the tornado damper installed at the outside air intake and the MCR fire dampers are designed to meet seismic Category II requirements, so that the failure of system components during a SSE will not reduce the functioning of any safety-related plant features. System equipment and ductwork located in the nuclear island, the failure of which could affect the operability of safety-related systems or components, are designed to seismic Category II requirements. The remaining portions of the system are non-seismic. Therefore, the system complies with GDC 2 requirements, as it relates to protection of the system against natural phenomena.

Redundant safety-related components of the MCR/TSC HVAC subsystem are physically separated, and are protected from internally-generated missiles, pipe breaks, and water spray. All safety-related components are seismic Category I, and designed to function following a SSE. The system design maintains its function with the loss of any single active component. In Sections 3.4.1, 3.5.1.1, 3.5.2, and 3.6.1 of this report, the staff documents its evaluation of the design to protect against floods, internally and externally-generated missiles, and high- and moderate-energy pipe breaks. On the basis that the MCR/TSC HVAC subsystem is designed to accomodate and be compatible with environmental conditions and consider dynamic effects, the staff concludes that the control room habitability systems satisfy GDC 4, as it relates to protecting the system against floods, internally-generated missiles, and piping failures.

As stated previously in Section 9.4 of this report, the HVAC design described in the DCD does not share SSCs with other nuclear power units. Therefore, the VBS meets the requirements of GDC 5.

COL applicants referencing the AP1000 design will identify the toxic gases to be monitored. Section 6.4 of this report discusses the specifics relating to compliance with GDC 19, as it pertains to protection of the control room against intrusion of toxic gases. As stated in that section, the compliance with GDC 19 in this regard is demonstrated by complying with the guidance of RG 1.78, Revision 1. Since the guidance of RG 1.78, Revision 1, is site dependent, it is within the scope of the COL applicant. Section 6.4 of this report also discusses compliance with GDC 19, as it relates to radiation dose limits for the control room operator.

The VBS is a non-radioactive HVAC system that serves areas where no radioactive sources are anticipated. Therefore, GDC 60 is not applicable.

As a result of the RTNSS process, short-term administrative controls are provided for the MCR ancillary fans that provide long-term cooling to the MCR and I&C rooms in the event of a total loss of ac power.

On the basis of the above review, the staff concludes that the VBS complies with GDC 2, 4, 5, 19, and 60, as referenced in Section 9.4.1 of the SRP, and consequently with the subject SRP acceptance criteria. However, the staff was unable to reach a conclusion because insufficient information was available at the time of review to resolve Open Item 9.4-1 concerning the codes and standards that are in effect as of the submittal date of the DCD Tier 2 (March 28, 2002) for the references identified in DCD Tier 2 Sections 6.4.8, 9.4.13, and Appendix 1A.

9.4.2 Annex/Auxiliary Buildings Nonradioactive HVAC System

The staff reviewed the VXS in accordance with the SRP Section 9.4.3, "Auxiliary and Radwaste Area Ventilation System." Conformance with the SRP acceptance criteria forms the basis for concluding whether the VXS satisfies the following requirements:

- GDC 2, regarding the capability to withstand earthquakes.
- GDC 5, regarding sharing systems and components important to safety.
- GDC 60, regarding the capability of the system to suitably control release of gaseous radioactive effluent to the environment.

The VXS is a nonradioactive HVAC system that serves the nonradioactive personnel and equipment areas; the electrical equipment rooms, clean corridors, ancillary diesel generator room, and demineralized water deoxygenating room in the annex building; and the MSIV compartments, reactor trip switchgear rooms, and piping and electrical penetration areas in the auxiliary building.

The VXS is not required to support any functions or operation of any equipment or systems listed in Regulatory Position C.1 of RG 1.29. Therefore, Regulatory Position C.1 of RG 1.29 is not applicable to the VXS. Additionally, the portions of the VXS located in areas containing

safety-related components will be seismically supported in accordance with Regulatory Position C.2 of RG 1.29. Therefore, the VXS conforms with GDC 2, "Design-Basis Protection Against Natural Phenomena."

The system description, design parameters, and P&IDs are provided in DCD Tier 2 Section 9.4.2, Table 9.4.2-1 through 9.4.2-7, and Figure 9.4.2-1, respectively. In DCD tier 2 Table 3.2-3, the applicant provides the classification of the VXS system and components. Table 9.4-1 of this report describes the industry standards applicable to the components of the VXS. The VXS supply airflow is balanced in accordance with the guidelines of SMACNA-1983, "HVAC Systems - Testing, Adjusting, and Balancing."

The VXS is designed to maintain proper operating temperatures in the following areas on the basis of the site interface parameters for maximum and minimum normal temperature conditions defined in DCD Tier 2 Table 2-1 and summarized as follows:

- for the annex building:

    - offices, corridors, locker rooms, toilet rooms, central alarm stations, and security areas between 22.8 °C to 25.6 °C (73 °F to 78 °F),

    - non-class 1E battery rooms between 15.6 °C to 32.2 °C (60 °F to 90 °F),

    - switchgear and battery charger rooms, HVAC and mechanical equipment room, and ancillary diesel generator room between 10 °C to 40.6 °C (50 °F to 105 °F), and

    - switchgear rooms, battery charger rooms, and ancillary diesel generator room during upset conditions (LOOP), with diesel generators operating, maximum temperature of 50 °C (122 °F).

- for the auxiliary building:

    - MSIV compartments, non-safety electrical penetration rooms, reactor trip switchgear rooms, and valve/piping penetration room between 10 °C to 40.6 °C (50 °F to 105 °F), and

    - Demineralized water deoxygenating room, elevator machine room, and boric acid batching room between 10 °C to 40.6 °C (50 °F to 105 °F).

The VXS protects against the buildup of hydrogen concentrations to less than 2 percent in the non-Class 1E battery rooms in the annex building.

DCD Tier 2 Section 7.3 describes the VXS instrumentation. The VXS is controlled by the plant control system (PLS). The temperature controllers maintain the proper air temperatures and provide indication and alarms that are accessible locally via the PLS. Temperature is indicated for each AHU supply air discharge duct, except for local recirculation units such as those in the MSIV compartments and valve/piping penetration room.

The VXS has the following six independent subsystems, as shown on DCD Tier 2 Figure 9.4.2-1:

- general area HVAC subsystem
- switchgear HVAC subsystem
- equipment room HVAC subsystem
- MSIV compartment heating and cooling subsystem
- mechanical equipment areas HVAC subsystem
- valve and piping penetration room HVAC subsystems

These subsystems are discussed below.

9.4.2.1 General Area HVAC Subsystem

The general area HVAC subsystem serves personnel areas in the annex building outside the security area, which include the men's and women's change rooms, shower/toilet areas, the ALARA briefing room and operational support center, offices, and corridors. The subsystem is not credited for plant abnormal conditions.

This subsystem consists of two 50-percent capacity supply AHUs, (5,100 scfm each), a humidifier, a ducted supply and return air system, diffusers and registers, exhaust fans, as well as associated dampers, instrumentation, and controls. The subsystem AHUs are located on the low roof of the annex building at Elevation 117'-6". During normal operation, both AHUs and the toilet/shower exhaust fan operate continuously to maintain the served areas within the design temperature range.

Each AHU of the general area HVAC subsystem consists of a centrifugal supply air fan, low-efficiency filter bank, high-efficiency filter bank, a hot water heating coil with integral face/bypass damper, and a chilled water cooling coil. The units discharge into a ducted supply distribution system, which is routed through the building to provide air into the various rooms and areas served via registers. The AHUs are controlled by temperature controllers, with their sensors located in the annex building main entrance. The temperature controllers modulate the chilled water control valves and the face and bypass dampers of the hot water heating coil in the AHUs. The switchover between cooling and heating modes is automatically controlled by the temperature controllers. Chilled and hot water is provided from the central chilled water system (VWS) and the plant hot water system (VYS), respectively. Outdoor makeup air is added at the AHU to replace air exhausted from the toilet and shower facilities in the annex building. A common steam humidifier is located in the ductwork downstream of the AHUs to provide a minimum space relative humidity of 35 percent with a humidistat control that is located in the main entrance of the annex building. The men's and women's locker room, and the toilet and shower facilities in the annex building have an exhaust fan that exhausts directly to the outside environment.

An electric heating coil provides tempering of the supply air inside the men's and women's facilities, and heating coil elements are controlled by a temperature controller with a sensor located in the women's facility.

To replace the AHU filters, the affected supply fan is stopped and isolated from the duct system by subsystem isolation dampers. In addition, the toilet/shower exhaust fan is also stopped. During filter replacement mode, the subsystem runs at 50 percent capacity and maintains the served areas in the annex building at a slight positive pressure.

9.4.2.2 Switchgear HVAC Subsystem

This subsystem serves the electrical switchgear rooms in the annex building. The subsystem consists of two 100-percent capacity AHUs, a ducted supply and return air system, and automatic controls and accessories. During normal plant operation, one AHU operates continuously to maintain the served areas within the design temperature. The AHU is controlled by a temperature controller to maintain the tempered air supply at 16.7 °C (62 °F) dependent on the outdoor ambient temperature conditions.

Each subsystem AHU consists of a centrifugal return/exhaust fan, return/exhaust air plenum, low-efficiency filter bank, high-efficiency filter bank, a hot water heating coil with integral face and bypass dampers, a chilled water cooling coil, and centrifugal supply fan. The AHUs discharge into a common duct supply distribution system, which is routed through the building to the various areas served. The air is then returned to the AHU. Chilled and hot water is provided from the VWS and VYS, respectively. The AHUs are located in the north air handling equipment room in the annex building at Elevation 135’-3". The AHUs are connected to a common plenum (which also supplies the outdoor air to the equipment room HVAC subsystem) located along the east wall adjacent to the air handling equipment room.

When the outdoor air temperature is above 16.7 °C (62 °F), the outdoor air, return air, and exhaust air dampers automatically reposition to provide minimum outdoor air, and the temperature controller modulates the chilled water control valves to maintain the supply air at 16.7 °C (62 °F). When the outside air temperature is below 16.7 °C (62 °F), each temperature controller modulates the outdoor air, return air, and exhaust air dampers to control a mixture of the return and minimum outdoor air in the proper proportion and modulates the face and bypass dampers of the hot water heating coils to maintain a mixed air temperature of 16.7 °C (62 °F).

To replace the AHU filters, the affected supply fan is stopped and the affected AHU is isolated from the duct system by subsystem isolation dampers. During filter replacement mode, the second AHU of the subsystem runs at full system capacity.

This subsystem is designed to remove smoke after a fire by placing the subsystem in a once-through smoke exhaust ventilation mode. Additionally, the alternate subsystem, which consists of 100-percent capacity supply and exhaust propeller fans (mounted in the annex building wall) and controls. The alternate subsystem provides cooling to electrical switchgear rooms 1 and 2 in the event that the primary subsystem AHUs are unavailable due to a fire. The switchgear rooms will be maintained at or below 50 °C (122 °F). The fans will be controlled to maintain the area above freezing.

In the event of a LOOP, the supply and return/exhaust fans are connected to the standby power system to provide the DID cooling function to the diesel bus switchgear. In this mode, outdoor air and return air volume dampers are positioned to the once-through flow mode to maintain the

switchgear rooms at or below 50 °C (122 °F), where equipment is designed for continuous operation under this environment. To maintain the areas above freezing, the mixing dampers will modulate to maintain a supply air temperature of 16.7 °C (62 °F) for outdoor temperatures below 16.7 °C (62 °F). For outdoor temperatures above 16.7 °C (62 °F), the outdoor air, return air, and exhaust air dampers are positioned for a once-through flow.

9.4.2.3 Equipment Room HVAC Subsystem

This subsystem serves the electrical and mechanical equipment rooms in the annex and auxiliary buildings. These rooms include non-Class 1E battery charger rooms 1 and 2, non-Class 1E battery rooms 1 and 2, non-class 1E penetration room on Elevation 100’-0" and non-class 1E penetration room on Elevation 117’-6", and reactor trip switch gear rooms I and II. It also serves the security area offices, and central alarm stations in the annex building (including rest rooms, access areas, and corridors).

This subsystem consists of two 100-percent capacity AHUs, two battery room exhaust fans, a toilet exhaust fan, a ducted supply and return air system, and automatic controls and accessories. During normal plant operation, one AHU operates continuously to maintain the served areas within the design temperature. The AHU is controlled by a temperature controller to maintain the tempered air supply at 16.7 °C (62 °F). Each subsystem AHU consists of a centrifugal return/exhaust fan, return/exhaust air plenum, low-efficiency filter bank, high-efficiency filter bank, a hot water heating coil with integral face and bypass, a chilled water cooling coil, and centrifugal supply fan.

The AHUs discharge into a common duct supply distribution system, which is routed through the building to the various areas served. The air is then returned to the AHU, except for the battery rooms and rest rooms. Chilled and hot water is provided from the VWS and VYS, respectively. The AHUs are located in the north air handling equipment room in the annex building at Elevation 135’-3". The AHUs are connected to a common plenum, which also supplies the outdoor air to the switchgear room HVAC subsystem, located along the east wall adjacent to the air handling equipment room.

When the outdoor air temperature is above 16.7 °C (62 °F), the outdoor air, return air, and exhaust air dampers automatically reposition to provide minimum outdoor air, and the temperature controller modulates the chilled water control valves to maintain the supply air at 16.7 °C (62 °F). When the outside air temperature is below 16.7 °C (62 °F), each temperature controller modulates the outdoor air, return air, and exhaust air dampers to control a mixture of the return and minimum outdoor air in the proper proportion. The face and bypass dampers, of the hot water heating coils, are also modulated to maintain a mixed air temperature of 16.7 °C (62 °F).

The electrical reheat coils are installed in the ductwork of non-Class 1E battery rooms, security area offices, and central alarm stations. The hot water unit heaters are provided in the north air handling equipment room and operate intermittently to maintain the area above 10 °C (50 °F). A steam humidifier is installed in the security areas ductwork to provide a minimum relative humidity of 35 percent.

A temperature controller opens the outdoor intake for the elevator machine room and starts and stops the elevator machine room exhaust fan, as required, to maintain the elevator machine room at design temperature conditions. A local thermostat controls the electric unit heater in the elevator machine room.

Each non-Class 1E battery room exhaust system consists of an exhaust fan, gravity back-draft damper, and associated ductwork located in the fan discharge, and exhausts to the atmosphere to prevent a hydrogen gas buildup above 2 percent. Air supplied to the battery rooms by the AHUs is exhausted to the atmosphere. Air from the rest room is exhausted to the atmosphere by a separate exhaust fan.

To replace the AHU filters, the affected supply fan is stopped and the affected AHU is isolated from the duct system by subsystem isolation dampers. During filter replacement mode, the second AHU of the subsystem runs at full system capacity.

The portion of the subsystem servicing the auxiliary building is designed so that smoke, hot gases, and fire suppressant will not migrate from one fire area to another to the extent that they could adversely affect safe shutdown capabilities, including operator actions. Fire or combination fire and smoke dampers, which close in response to smoke detector signals or in response to the heat from a fire, are provided to isolate each fire area from adjacent fire areas during and following a fire, in accordance with NFPA 90A requirements.

In the event of a LOOP, the supply and return/exhaust fans are connected to the standby power system to provide the DID cooling function to the dc switchgear and inverters. In this mode, outdoor air and return air volume dampers are positioned to the once-through flow mode to maintain the dc switchgear and inverter areas at or below 50 °C (122 °F). The equipment is designed for continuous operation under this environment. To maintain the areas above freezing, the mixing dampers will modulate to maintain a supply air temperature of 16.7 °C (62 °F) for outdoor temperature below 16.7 °C (62 °F). For outdoor temperatures above 16.7 °C (62 °F), the outdoor air, return air, and exhaust air dampers are positioned for a once-through flow.

9.4.2.4 Main Steam Isolation Valve HVAC Subsystem

The MSIV HVAC subsystem serves the two MSIV compartments in the auxiliary building that contain the main steam and feedwater piping. The main steam and feed water lines between the turbine building and containment are routed through two separate compartments in the auxiliary building. This subsystem is not credited for plant abnormal conditions.

The MSIV HVAC subsystem consists of two 100-percent capacity AHUs in each compartment (3300 scfm each), supply and air distribution ducting, and automatic controls and accessories. During normal plant operation, one of the AHUs in each compartment operates continuously in a recirculation mode to maintain the design temperature range in the area served by the system.

Each AHU consists of a low-efficiency filter bank, a hot water heating coil, a chilled water cooling coil, a centrifugal supply air fan, and associated instrumentation and controls. Chilled and hot water is provided from the VWS and VYS, respectively. Two inside air temperature

indicators are provided for each compartment. The switchover between cooling and heating modes is automatically controlled by the area temperature controller.

The temperature of the MSIV compartment is maintained at or less than 40.6 °C (105 °F) and above a minimum of 10 °C (50 °F) by a temperature controller that modulates the chilled water and hot water control valves serving each unit. For investment protection, the subsystem can be powered by the standby power system in the event of a LOOP.

The AHU may be shut down for replacement while another AHU in the same MSIV compartment operates to maintain the served area within the design temperature range. The AHUs can be connected to the standby power system during a LOOP event for investment protection.

9.4.2.5 Mechanical Equipment Areas HVAC Subsystem

The mechanical equipment areas HVAC subsystem serves the ancillary diesel generator (DG) room, the demineralized deoxygenating room, boric acid batching room, and upper and lower south air handling equipment rooms in the auxiliary building. This subsystem maintains served areas at a slightly positive pressure with respect to the adjacent buildings by supplying a constant volume of outside air. This subsystem is not credited for plant abnormal conditions.

The mechanical equipment areas HVAC subsystem consists of two 50-percent capacity AHUs with supply fans and return/exhaust fans (2,200 scfm each), a ducted supply and return air system, and automatic controls and accessories. During normal plant operation, the AHUs operate continuously to maintain the served areas within design temperature range. To replace the AHU filters, the affected AHU is stopped and isolated from the duct system by subsystem isolation dampers. During filter replacement mode, the subsystem operates at approximately 50-percent capacity.

Each subsystem AHU consists of a return/exhaust fan, return/exhaust air plenum, low-efficiency filter bank, high-efficiency filter bank, a hot water heating coil with integral face/bypass damper, chilled water cooling coil, centrifugal fan, and associated instrumentation and controls. Chilled and hot water is provided from the VWS and VYS, respectively. The AHUs are located in the lower south air handling equipment room on Elevation 135’-3" of the annex building. The outdoor air is supplied from the (non-tornado missile protected) air intake plenum #2, which also serves the VAS, VHS, and VFS, located at the extreme south end of the annex building, between Elevations 135’-3" and 158’-0".

The air temperature indicators are provided in side the lower south air handling equipment room. The temperature of the area is maintained by temperature controllers with sensors located in the upper south air handling equipment room. The temperature controllers modulate the chilled water control valves and the face and bypass dampers, of the hot water heating coil in the AHUs, to maintain the areas served by the subsystem within the design temperature range. The switchover between cooling and heating modes is automatically controlled by the area temperature controller.

The ancillary DG room is served by the subsystem and maintained within the design temperature range when the ancillary DGs are not in operation. The air supplied to the DG

room is exhausted to the outdoors by means of a separate exhaust fan. The exhaust fan for the ancillary diesel generator room operates continuously for room ventilation. The ancillary DG room is supplied air from the AHUs to maintain normal temperatures. Ventilation and cooling for the ancillary diesel generators is provided by means of manually operated dampers and opening room doors to allow radiator discharge air to be exhausted direct to outdoors.

9.4.2.6 Valve and Piping Penetration Room HVAC Subsystem

The valve and piping penetration room HVAC subsystem consists of local recirculation HVAC units to cool the valve/piping penetration room located at Elevation 100’-0" of the auxiliary building. The subsystem is not credited for plant abnormal conditions.

The valve/piping penetration room HVAC subsystem consists of two 100-percent capacity AHUs, and is provided with an automatic ducted supply (1,800 scfm each) and return air system, and automatic controls and accessories. The AHUs are located directly within the space served on Elevation 100’-0". During normal operation, one AHU operates continuously in a recirculation mode to maintain the served area within the design temperature range.

Each subsystem AHU consists of a low-efficiency filter, a hot water heating coil, a chilled water cooling coil, centrifugal supply air fan, and associated instrumentation and controls. Chilled and hot water is provided from the VWS and VYS, respectively. Two inside air temperature indicators are provided for each valve and piping penetration room HVAC subsystem. The switchover between cooling and heating modes is automatically controlled by the area temperature controller.

The temperature controllers, with sensors located in the room, modulate the chilled water control valves and the hot water control valves in the operating AHU. The temperature of valve/piping penetration room is maintained at or less than 40.6 °C (105 °F) and above a minimum of 10 °C (50 °F) by a temperature controller that modulates the chilled water and hot water control valves serving each unit.

The hot water and electric unit heaters are controlled by local thermostats. The area temperature indication is accessible from the MCR. The pressure indication and high differential pressure alarm are provided for each of the filters in the AHUs for filter replacement. The operational status of fans is indicated in the MCR and position indicating lights are provided for automatic dampers. The air flow is indicated for the discharge ducts of the AHUs and alarms for low flow rates are provided in the fan discharge ducts. Smoke alarms are provided in the discharge ducts of the AHUs.

9.4.2.7 Conclusion

The VXS is non-safety-related; therefore, Regulatory Position C.1 of RG 1.29 is not applicable to the VXS. Additionally, the portions of the VXS located in areas containing safety-related components will be seismically supported in accordance with Regulatory Position C.2 of RG 1.29. System equipment and ductwork located in the nuclear island, the failure of which could affect the operability of safety-related systems or components, are designed to seismic Category II requirements. The remaining portions of the system are non-seismic. Therefore, the VXS conforms with GDC 2.

As stated previously in Section 9.4 of this report, the HVAC design described in the DCD does not share SSCs with other nuclear power units. Therefore, the VXS meets the requirements of GDC 5.

The VXS is a non-radioactive HVAC system that serves areas where no radioactive sources are anticipated. Therefore, GDC 60 is not applicable.

The staff evaluated the VXS for conformance with GDC 2, 5, and 60, as referenced in Section 9.4.3 of the SRP, and concludes that the design of the VXS is acceptable.

9.4.3 Radiologically Controlled Area Ventilation System

The staff reviewed the VAS in accordance with SRP Sections 9.4.2, "Spent Fuel Pool Area Ventilation System," and 9.4.3. Conformance with the SRP acceptance criteria forms the basis for concluding whether the VAS satisfies the following requirements:

- GDC 2, regarding the capability to withstand earthquakes,

- GDC 5, regarding sharing systems and components important to safety,

- GDC 60, regarding the capability of the system to suitably control release of gaseous radioactive effluent to the environment, and

- GDC 61, regarding the capability of the system 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.

The VAS neither serves nor supports the plant safety-related functions; therefore, the system has no nuclear safety design basis. The VAS consists of the following two subsystems:

- the auxiliary/annex building ventilation subsystem (AABVS), and
- the fuel-handling area ventilation subsystem (FHAVS).

The VAS serves the fuel-handling area of the auxiliary building, and the radiologically controlled portions of the auxiliary and annex buildings. The VAS maintains environmental conditions appropriate for equipment operation, for performing maintenance and testing, and to allow personnel access. The VAS ventilation airflow rate dilutes potential airborne contamination to within the effluent concentration limits allowed by 10 CFR Part 20 at the site boundary during normal plant operation. The plant's internal airborne concentration levels will conform to the 10 CFR Part 20 occupational derived air concentration limits.

The VAS maintains normal airflow direction from lower to higher potential airborne concentrations for ALARA considerations. The design of the VAS exhaust subsystems conforms with the requirements of Appendix I to 10 CFR Part 50 for releases during normal operation. Upon detection of high airborne radioactivity in the air exhaust duct or high ambient pressure differential (resulting from an imbalance in supply and exhaust airflow rates), unfiltered normal VAS exhaust is isolated. In addition, the VFS filtered exhaust subsystem starts to provide filtration of the exhaust air from the fuel-handling area (as well as the auxiliary and

annex buildings) to minimize unfiltered offsite releases. These areas are maintained at a slight negative pressure with respect to the adjacent clean areas when high airborne radioactivity is detected. The VFS mitigates exfiltration of unfiltered airborne radioactivity by maintaining the isolated zone at a slightly negative pressure with respect to the outside environment and adjacent unaffected plant areas. The VFS maintains a slightly negative pressure differential with respect to the outside environment until operation of the AABVS and FHAVS are restored.

The AABVS supply and exhaust ducts are configured into two independently isolatable building zones. A radiation monitor is located in the exhaust duct, upstream of an isolation damper in each zone served by AABVS. The FHAVS supply and exhaust ductwork is arranged to exhaust the spent fuel pool plume and to provide directional airflow from the rail car bay/filter storage area into the spent fuel resin equipment rooms. The FHAVS contains a radiation monitor that is mounted upstream of an isolation damper in the exhaust duct. The AABVS' and FHAVS' unfiltered, but monitored, exhaust is routed to the plant vent during normal operation. However, if high radioactivity is detected, the subsystems' exhaust is filtered through the VFS and then routed to the plant vent. The staff's review of radiation monitoring is discussed in Section 11.5 of this report. In conjunction with the VFS as described above, the VAS provides appropriate containment, confinement, and filtering to limit releases of airborne radioactivity to the environment from the fuel storage facility during normal and postulated accident (non-DBA) conditions, in accordance with GDC 61. However, no credit for these features is assumed in the determination of the radiological consequences of a fuel-handling accident. The radiological consequences of a fuel-handling accident are discussed in Section 15 of this report.

Each radwaste effluent holdup tank exhaust is connected to the AABVS exhaust ducting, to prevent the potential buildup of airborne radioactivity or hydrogen gas that may leak within the tanks. The exhaust is then routed to the plant vent through the VFS. The AABVS provides sufficient ventilation to the gaseous radwaste equipment areas to dilute hydrogen gas that may leak from the radwaste equipment into the equipment rooms. The hydrogen gas concentration is maintained below a safe level (of about 1 percent) which conforms with the guidelines of SRP Section 11.3. The hydrogen monitoring instrumentation is described in DCD Tier 2 Table 11.3-2. An evaluation of the gaseous waste management system is provided in Section 11.3 of this report.

The VAS description, component design parameters, and P&IDs are given in DCD Tier 2 Section 9.4.3, Tables 3.2-3 and 9.4.3-1, and Figure 9.4.3-1, respectively. Table 9.4-1 in this report describes the industry standards applicable to the components of the VAS. The VAS supply airflow is balanced in accordance with the guidelines of SMACNA-1983, "HVAC Systems - Testing, Adjusting, and Balancing."

The VAS is a once-through design that draws outdoor air and exhausts the air to the plant vent. During normal plant operation, VAS supply air handling units and exhaust fans for both the AABVS and FHAVS operate continuously to ventilate the areas on a once-through basis. The VAS air handling units are automatically shut down if airflow or supply air temperature is below a predetermined setpoint. Temperature controllers maintain proper supply air temperature to maintain the ambient room temperature within the normal range. The temperature of the air supplied by each AHU of the AABVS and FHAVS is controlled by temperature sensors in the supply air duct. When the outdoor air temperature is low, the face and bypass dampers across

the supply air heating coil are modulated to maintain the ambient room temperature. When the outdoor air temperature is high, the supply air is tempered by the chilled water coil. The supply of chilled and hot water for the VAS is provided from the VWS and VYS, respectively.

The VAS cooling and heating capacity is dependent on the site interface parameters for maximum and minimum normal temperature conditions, as defined in DCD Tier 2 Table 2-1. The annex building staging areas and storage areas, as well as other corridors and staging areas are maintained between 10 °C and 40 °C (50 °F and 104 °F). The corridors and access areas served by the FHAVS is maintained between 10 °C and 40 °C (50 °F and 104 °F). The radiation chemistry laboratory and security rooms are served by the AABVS and are maintained between 22.8 °C and 25.6 °C (73 °F and 78 °F). The primary sample room is served by the AABVS and is maintained between 10 °C and 40 °C (50 °F and 104 °F).

DCD Tier 2 Section 7.3 describes the VAS instrumentation. The VAS is controlled by the PLS. The temperature controllers maintain the proper air temperatures and provide indications and alarms. The pressure differential indications and alarms monitor the outside air and inside ambient pressures of the fuel-handling area and auxiliary/annex buildings, and control the supply air flow to maintain a slightly negative pressure differential with respect to adjacent clean areas and outdoors. The area temperature indication is accessible from the MCR for the RNS and makeup pump rooms without requiring personnel access to these rooms. Auxiliary building and fuel-handling area radiation monitoring instrumentation (radiation detectors) is provided in the system exhaust ducts upstream of the isolation dampers. As described above, upon detection of high airborne radioactivity in the air exhaust duct or high ambient pressure differential, the unfiltered exhaust air ducts automatically isolate and the VFS filtered exhaust automatically starts. The MCR is provided with indication and alarms in the exhaust ducts from the fuel-handling area and radiologically controlled areas of the auxiliary and annex buildings. Operational status of fans and dampers is indicated in the MCR. All fans and AHUs can be operated or shutdown from the MCR. Pressure indications and high differential pressure alarms for the system filters and unit coolers are provided.

During normal operation, The AABVS and FHAVS ventilation air is continuously monitored by smoke monitors located downstream of the AHUs and upstream of the exhaust fans. The supply AHUs are automatically shutdown if airflow rate of the fans or air temperature is detected below a predetermined set point.

During abnormal plant operation, if smoke is detected in the supply or exhaust ducts, an alarm is initiated in the MCR. HVAC subsystems remain in operation but may be shutdown manually by MCR operators, as needed. In the event of a fire occurring within the served areas, local fire dampers automatically isolate the HVAC ductwork penetrating the affected fire area upon exceeding the predetermined setpoints of the local temperature.

9.4.3.1 Auxiliary/Annex Building Ventilation Subsystem (AABVS)

The AABVS supply and exhaust ducts are configured into two zones. The annex building staging and storage area, containment air filtration rooms, containment access corridor, and adjacent auxiliary building staging area, equipment areas, middle annulus, middle annulus access room, and security rooms are served by one zone. The other zone includes the remaining rooms and corridors shown in Figure 9.4.3-1, Sheet 2 of 3, including but not limited

to the radiation chemistry laboratory, primary sample room, spent fuel pool cooling water pump and heat exchanger rooms, RNS pump and heat exchanger rooms, CVS makeup pump room, lower annulus, and various radwaste equipment rooms, pipe chases, and accesses corridors. The AABVS provides conditioned air to maintain the proper operating temperatures in the following areas:

- the RNS and CVS pump rooms (pumps not operating), containment purge exhaust filter rooms (fans not operating), liquid radwaste pump rooms, HVAC equipment room, gaseous equipment rooms, and spent fuel pool pump and heat exchanger rooms between 10 °C and 40 °C (50 °F and 104 °F), and

- the degasifier column, RNS and CVS pump rooms (pumps operating), containment purge exhaust filter rooms (fans operating), and liquid radwaste tank rooms between 10 °C and 54.4 °C (50 °F and 130 °F).

The supply air flow rate is modulated to maintain a slightly negative pressure differential with respect to the outside environment. Provision for supplementary heating is made for the exterior annex/auxiliary building areas through the annex building heating coil. The AABVS consists of two 50-percent capacity supply AHUs (18,000 scfm each), two 50-percent capacity exhaust fans sized to allow the AABVS to maintain a negative pressure in served areas with respect to the adjacent areas, associated ductwork, dampers, diffusers and registers, and instrumentation and controls. Each AHU consists of a centrifugal supply air fan, a low-efficiency filter bank, a high-efficiency filter bank, a water heating coil with integral face and bypass dampers, a chilled water cooling coil, and associated instrumentation and controls. The supply AHUs are located in the south air handling equipment room of the annex building at Elevation 158'-0" and are connected to a common air intake plenum #3. The common, non-tornado missile protected, air intake plenum #3 is located at the extreme south end of the annex building between Elevation 158'-0" and about 180'-0". Each subsystem AHU discharges into a ducted supply distribution system, which is routed through the radiologically controlled areas of the auxiliary and annex buildings.

The AABVS exhaust fans are located in the auxiliary building at Elevation 145'-9". The supply and exhaust ducts have isolation dampers. During normal operation, the subsystem's exhaust is unfiltered and directed to the plant vent for discharge. During high radiation isolation mode, the normal unfiltered ventilation subsystem is isolated from the affected zone when high airborne radioactivity is detected, and the isolated area is exhausted through the VFS to the monitored plant vent. The VFS exhaust fans prevent unfiltered airborne releases by maintaining these areas at a slight negative pressure with respect to the outside environment and adjacent clean plant areas.

Each CVS makeup and normal RNS pump room is provided with a dedicated, 100 percent capacity unit cooler (for a total of two per CVS and RNS pump room) to provide supplemental cooling during pump operation. The chilled water to coolers is supplied from redundant trains of the VWS. Each unit cooler consists of a low-efficiency filter bank, a cooling coil bank and fan, except that each RNS pump room cooler has redundant cooling coil banks. Therefore, either redundant train of the VWS can support the operation of both RNS pumps simultaneously. The CVS pump room coolers are connected to redundant trains of the VWS; however, either train unit cooler can maintain the common makeup pump room temperature

conditions and support either makeup pump operation. The pump room coolers automatically start whenever the associated pump receives a start signal or a high room temperature signal. In a LOOP event, the unit coolers can be powered by the onsite diesel generators.

The upper annulus is separated from the middle annulus area of the auxiliary building by a concrete floor section and flexible seals that connect the containment steel shell to the shield building. The annulus seal provides a passive ventilation barrier during normal operation or during isolation of the auxiliary building to prevent the exfiltration of unmonitored releases from the middle annulus to the environment.

The radiation chemistry laboratory and security room supply air ducts are supplemented with locally installed electric coils and humidifiers to maintain environmental conditions within the areas suitable for personnel comfort. The electric unit heaters provide supplemental heating in the middle annulus as shown in DCD Tier 2 Figure 9.4.3-1.

9.4.3.2 Fuel-Handling Area Ventilation Subsystem (FHAVS)

The FHAVS serves the fuel handling area, rail car bay/filter storage area, resin transfer pump/valve room, spent resin tank room, waste disposal container area, WSS (spent resin) valve/piping area, and elevator machine room.

The FHAVS provides air to maintain the following conditions:

- the rail car bay/filter storage area between 10 °C and 40 °C (50 °F and 104 °F),
- the spent resin equipment rooms between 10 °C and 54.4 °C (50 °F and 130 °F),
- the fuel handling area between 10 °C and 35.6 °C (50 °F and 96 °F), and
- a maximum wet bulb temperature of 26.7 °C (80 °F), within the guidelines of Electric Power Research Institute (EPRI) NP-4453, in the areas occupied by plant personnel during refueling activities.

The supply air flow is modulated to maintain the served areas at a slight negative pressure differential with respect to the outside environment. Provision for supplementary heating is made for the rail car bay through the rail car bay heating coil. The FHAVS consists of two 50-percent capacity supply AHUs (9,500 scfm each), two 50-percent capacity exhaust fans sized to allow the FHAVS to maintain a negative pressure in served areas with respect to the adjacent areas, associated ductwork, dampers, and instrumentation and controls. Each AHU consists of a centrifugal supply air fan, a low-efficiency filter bank, a high-efficiency filter bank, a water heating coil with integral face and bypass damper, a chilled water cooling coil, and associated instrumentation and controls. These areas form a single isolation zone when high airborne radioactivity is detected in the exhaust air. The supply AHUs are located in the south air handling equipment room of the annex building at Elevation 135'-3" and connected to a common air intake plenum #2 located at the south end of annex building. The common, non-tornado missile protected, air intake plenum #2 is located at the south end of the annex building between Elevation 135'-3" and about 158'-0". Each subsystem AHU discharges into a

ducted supply distribution system, which is routed to the fuel-handling area and rail car bay/filter storage areas of the auxiliary building.

The FHAVS supply AHUs are located in the south air handling equipment room of the annex building at Elevation 135'-3", and the exhaust fans are located in the upper radiologically controlled area ventilation system equipment room at Elevation 145'-9" of the auxiliary building. The exhaust has isolation dampers. During normal operation, the subsystem's exhaust is unfiltered and directed to the plant vent for discharge and monitoring of offsite gaseous releases. During high radiation isolation mode, the normal unfiltered ventilation subsystem is isolated from the affected zone when high airborne radioactivity is detected, and the isolated area is exhausted through the VFS to the monitored plant vent.

9.4.3.3 Conclusion

As described in DCD Tier 2 Section 9.4.3 and Table 3.2-3, the VAS is located completely within a seismic Category I auxiliary building and seismic Category II annex building structures, and all system components are non-safety-related. Regulatory Position C.1 of RG 1.29 is not applicable because the FHAVS is not credited for the mitigation of the fuel-handling accident (FHA), and therefore, it is not required to remain functional after a SSE. Compliance with Regulatory Position C.2 of RG 1.29 is demonstrated in the evaluation of the FHAVS for interaction with seismic Category I systems in Section 3.7.3 of this report. The evaluation demonstrates that seismic failure of the FHAVS does not reduce the functioning of the safety-related plant features. System equipment and ductwork located in the nuclear island, the failure of which could affect the operability of safety-related systems or components, are designed to seismic Category II requirements. The remaining portion of the system is non-seismic. The AABVS is not credited for any DBA conditions, and therefore, it is not required to remain functional after a SSE. The makeup pump and RNS pump room coolers and exhaust fans for the AABVS are located in the seismic Category I auxiliary building. Therefore, the VAS complies with the requirements of GDC 2.

As stated previously in Section 9.4 of this report, the HVAC design described in the DCD does not share SSCs with the other nuclear power units. Therefore, the VAS meets the requirements of GDC 5.

As discussed above, the subsystems' unfiltered, but monitored exhaust is routed to the plant vent during normal operation. If high radioactivity is detected, the subsystems' exhaust is filtered through the VFS, and then routed to the plant vent. This is in compliance with the guidelines of RG 1.140 for controlling the release of radioactivity, as discussed in DCD Tier 2 Chapter 1.0, Appendix 1A. As discussed in Section 9.4.7 of this report, the VFS filtration units are designed, constructed, and tested to conform with ASME/ANSI AG-1-1997 and Addenda AG-1a-2000, ASME N509 and N510 standards, and the guidelines of RG 1.140, Revision 2. Therefore, the VAS also complies with the requirements of GDC 60, as it relates to the capability of the system to suitably control the release of gaseous radioactive effluent to the environment.

The VFS filtration units, where the VAS radioactive exhaust is filtered, conforms with Regulatory Position C.4 of RG 1.13, as discussed in DCD Tier 2 Chapter 1, Appendix 1A. Consequently, the system complies with the requirements of GDC 61, as it relates to the capability of the

system to provide appropriate containment, confinement, and filtering to limit releases of airborne radioactivity to the environment.

The staff evaluated the VAS for conformance with GDC 2, 5, 60, and 61, as referenced in SRP Sections 9.4.2 and 9.4.3. As discussed above, the staff found that the VAS meets GDC 2, 5, 60, and 61. Therefore, the staff concludes that the VAS design is acceptable.

9.4.4 Balance of Plant Interfaces

The AP1000 is a complete design; therefore, balance-of-plant interfaces are not applicable to this design.

9.4.5 Engineered Safety Features Ventilation System

The staff evaluated the non-safety-related HVAC systems against the RTNSS criteria. The staff concluded that none of the HVAC systems are ESF ventilation systems, and that no HVAC system is required to support non-safety-related systems that are determined to be important by the RTNSS process, on the basis of the following:

- Except for the VES and portions of the VBS, all of the HVAC systems are not safety-related and are not RTNSS systems. The portions of the VBS that are part of the RTNSS process consist of the short-term administrative controls provided for the MCR ancillary fans (as discussed in Section 22.5.4.3 of this report). The safety-related VES is credited to meet the requirements of GDC 19, during a design-basis LOCA, and is evaluated in Section 6.4 of this report.

- The VBS provides safety-related design basis functions to (1) monitor the air supply for radioactive particulate and iodine concentrations inside the MCRE, and (2) isolate the safety-related, seismic Category I HVAC piping penetrating the MCRE upon detecting "high-high" particulate or iodine radioactivity in the supplied air. The VBS is non-safety-related except as described above and is not credited to meet the requirements of GDC 19, during a design-basis LOCA. The non-safety-related VBS is evaluated in Section 9.4.1 of this report.

- The VFS is not required to mitigate the consequences of a design-basis fuel-handling accident or a LOCA. The VFS was evaluated in accordance with the SRP Section 9.4.5, "Engineered Safety Features Ventilation System." The system serves no safety-related function other than containment isolation, and its operation is not required following a DBA. The non-safety-related VFS is evaluated in Section 9.4.7 of this report.

- No other non-safety-related HVAC systems are credited in the accident dose analyses or provide any safety-related design-basis functions. Other HVAC systems are evaluated in Sections 9.4.2, 9.4.3, 9.4.6, and 9.4.8 through 9.4.11 of this report.

9.4.6 Containment Recirculation Cooling System

The staff reviewed the VCS in accordance with SRP Section 9.4.5. Conformance with the SRP acceptance criteria forms the basis for concluding whether the VCS satisfies the following requirements:

- GDC 2, regarding the capability to withstand earthquakes,
- GDC 4, regarding maintaining environmental conditions in essential areas compatible with the design limits of the essential equipment located therein during normal, transient, and accident conditions,
- GDC 5, regarding sharing systems and components important to safety,
- GDC 17, "Electric Power System," regarding the assurance of proper functioning of essential electric power systems, and
- GDC 60, regarding the capability to suitably control release of gaseous radioactive effluent to the environment.

The VCS is a non-safety-related ventilation system that is not required to mitigate the consequences of a DBA or LOCA. If the VCS is available following abnormal operational transients, fan coil units can be operated at slow speed for post-event recovery operations to lower the containment temperature and pressure. The VCS is supplemented by a maintenance space ventilation subsystem with a portable exhaust filtration unit. This subsystem is used during shutdown and refueling operation to protect maintenance personnel and to control the spread of airborne contamination from the steam generator compartments to the other containment areas. During integrated leak rate testing (ILRT) operation, the VCS fans are operated at slow speed in order not to exceed their rated horsepower, which could affect the ILRT results.

The VCS operates during normal plant operation and shutdown to maintain suitable temperatures in the served areas of the containment building. The two fan coil unit (FCU) assemblies are located on a platform at Elevation 153'-0", approximately 180 degrees apart to provide proper mixing of return and supply air. The top of the ring header is at Elevation 176'-6". System equipment and ductwork located in the nuclear island, the failure of which could affect the operability of safety-related systems or components, are designed to seismic Category II requirements. The remaining portion of the system is non-seismic.

The system description, component design parameters, and P&ID are provided in DCD Tier 2 Section 9.4.6, Table 9.4.6-1, and Figure 9.4.6-1, respectively. Table 9.4-1 of this report describes the industry standards applicable to the components of the VCS. The VCS airflow is balanced in accordance with SMACNA-1993, "HVAC Systems - Testing, Adjusting, and Balancing."

The VCS maintains temperatures in the served areas below 48.9 °C (120 °F) during normal operation. The VCS also maintains the reactor cavity area average concrete temperature at 65.6 °C (150 °F), with a local area temperature of 93.3 °C (200 °F). During refueling and plant

shutdown, the served areas bulk air temperature is maintained below 21.1 °C (70 °F) and above 10 °C (50 °F) for personnel access and equipment operability.

As stated in DCD Tier 2 Section 9.4.6.2 and Table 9.4.6-1, and as shown in DCD Tier 2 Figure 9.4.6-1, the VCS has two 100-percent FCU assemblies, each with two separate, but physically connected, 50-percent capacity FCUs. Each FCU assembly draws air from the upper levels of the operating floor and delivers tempered air through the ring header and the secondary duct distribution system to the cubicles, compartments, and access areas above and below the operating floor, including the reactor cavity and reactor support areas. As the tempered air absorbs the heat released from the various components inside containment, return air rises through vertical passages and openings where it is again returned into the FCUs, tempered, dehumidified, and recirculated.

Each FCU assembly consists of two 50-percent capacity FCUs. Each FCU contains a vane axial, upblast, direct-driven fan with a two-speed motor; return air mixing plenum section with a physical barrier in the middle; and three chilled water cooling coils attached to the side of each plenum section. The fans operate in high speed during normal operation and low speed for high ambient air density conditions, such as during ILRT and abnormal post-event recovery operation.

The supply of the chilled and hot water is provided from the VWS and VYS, respectively. The cross-connections for VWS and VYS are located outside containment. The water piping inside containment is common to both the VWS and VYS.

To meet the environmental design criteria during various modes of VCS operation, temperature controllers are provided in the ring headers of the corresponding FCU, which provide an input signal to modulate the VWS supply valves to the cooling coils to maintain the normal air supply at 15.6 °C (60 °F). The standby FCUs start automatically if the discharge flow rate from the operating FCU drops below a predetermined setpoint, if the discharge temperature from the operating FCU is above or drops below a predetermined setpoint, and if electrical and/or control power is lost. The FCU fans are connected to 480 V buses with backup power supply from the onsite standby diesel generators.

A steam generator maintenance space ventilation subsystem is employed through the compartment supply air ducts during reactor shutdown for personnel access and maintenance activities. This vacuum system protects personnel and controls the spread of airborne radioactive contamination from the steam generator compartments to the other containment areas. The subsystem consists of permanently installed exhaust ductwork with flexible hose connections in the vicinity of steam generator channel heads, which can be connected to a portable exhaust filtration unit (which does not exhaust outside of containment). During subsystem operation, the supply air distribution ductwork is isolated by closing relevant supply dampers.

The VCS instrumentation is described in DCD Tier 2 Section 7.3. The VCS is monitored by the plant monitoring system and controlled by the plant control system. The indication of the operational status and controls of the equipment inside the containment is provided in the MCR. Temperature indications and alarms are provided in the equipment compartment or areas of the containment to maintain the supply air temperature within a predetermined range.

The containment and equipment compartment temperatures are monitored from the MCR. The FCU discharge flow is monitored and low flow is alarmed to alert the MCR operator to start the spare FCU manually. The reactor cavity areas are also monitored and alarmed for low flow condition.

Regulatory Position C.1 of RG 1.29 does not apply to the VCS because it is not designed to perform any safety functions. Instead, the VCS complies with Regulatory Position C.2 of RG 1.29 for the following reasons:

- System equipment and ductwork located in the nuclear island, the failure of which could affect the operability of safety-related systems or components are designed to seismic Category II requirements. The remaining portions of the system are non-seismic.

- The VCS is evaluated for interaction with seismic Category I systems in DCD Tier 2 Section 3.7.3.13 to ensure that the VCS does not reduce the functionability of any safety-related plant features. Seismic interaction is evaluated in Section 3.7.3 of this report.

The staff finds this meets Regulatory position C2 of RG 1.29 and is acceptable. Therefore, the system complies with the requirements of GDC 2.

As stated previously in Section 9.4 of this report, the HVAC system design described in the DCD does not share SSCs with other nuclear power units. Therefore, the VCS meets the requirements of GDC 5.

The staff determined that the VCS is not an ESF system, the system is not credited in analyzing the consequences of DBA, and the system does not exhaust to the environment. Therefore, the requirements of GDC 4, 17, and 60 are not applicable.

The staff evaluated the VCS for conformance with GDC 2, 4, 5, 17 and 60 as referenced in SRP Section 9.4.5 and found that the VCS met the applicable GDCs. Therefore, the staff concludes that the VCS design is acceptable.

9.4.7 Containment Air Filtration System

The staff reviewed the VFS in accordance with SRP Section 9.4.5. Conformance with the SRP acceptance criteria forms the basis for concluding whether the VFS satisfies the following requirements:

- GDC 2, regarding the capability to withstand earthquakes.

- GDC 4, regarding maintaining environmental conditions in essential areas compatible with the design limits of the essential equipment located therein during normal, transient, and accident conditions.

- GDC 5, regarding sharing systems and components important to safety.

- GDC 17, regarding the assurance of proper functioning of essential electric power systems.
- GDC 60, regarding the capability to suitably control release of gaseous radioactive effluent to the environment.
- GDC 61, regarding the capability of the system to provide appropriate containment, confinement, and filtering to limit releases of airborne radioactivity to the environment.

The VFS is not required to mitigate the consequences of a design-basis FHA or a LOCA. The system serves no safety-related function other than containment isolation, and its operation is not required following a DBA. The containment isolation components are safety Class B and seismic Category I, and the quality assurance requirements of 10 CFR Part 50, Appendix B are applicable.

The components include air-operated, fail-close (during loss of power or loss of air pressure) containment isolation valves (CIVs), penetrations, interconnecting piping, and vent and test connections with manual valves. The size of supply and exhaust air lines that penetrate the containment pressure boundary is 914.4 mm (36 in.) in diameter. Each penetration includes inboard and outboard branch connections with 406.4 mm (16 in.) diameter CIVs that are opened when the VFS is aligned to containment. The other ends of the containment penetrations are capped with 914.4 mm (36 in.) diameter blind flanges for installation provisions for a high-volume purge system on a site-specific basis.

The seismic Category I debris screens are designed for post-LOCA pressures and mounted on safety Class C, seismic Category I piping between the containment atmosphere and the CIVs. This prevents entrainment of debris through the supply and exhaust opening that may prevent a tight valve shut off against the containment pressure. The CIVs in the supply and exhaust air subsystems automatically close upon receiving a containment isolation signal or a containment area high radiation signal. The CIVs are designed to shut tight when subject to the containment pressure following a DBA. The containment isolation function is evaluated and found acceptable in Section 6.2.3 of this report.

The VFS also provides the following functions:

- flow of outdoor air for containment purging to reduce the airborne radioactivity to an acceptable level for personnel access intermittently during normal plant operation and continuously during hot or cold plant shutdown conditions,
- containment pressure control within its normal design pressure range by intermittent venting of air into and out of the containment,
- filtration of exhaust air before discharge to the plant vent in accordance with the guidelines of 10 CFR Part 50, Appendix I for offsite releases and 10 CFR Part 20 allowable effluent concentration limits, when combined with other gaseous effluent releases, for the site boundary release,

- monitoring gaseous, particulate, and iodine concentration levels discharged to the environment through the plant vent,
- conditioning and filtration of outside air for suitable environmental conditions for personnel comfort inside the containment during access for maintenance and refueling operations, and
- filtration of exhaust air from the fuel-handling area, and auxiliary or annex buildings, and maintaining these areas at a slight negative pressure with respect to the adjacent clean areas through the VFS exhaust air subsystem.

The VFS is designed to maintain the supply air temperature range between 10° C and 21.1° C (50° F and 70° F) inside containment, dependent on maximum and minimum normal outside temperature conditions shown in DCD Tier 2 Chapter 2, Table 2-1. The supply air is distributed and conditioned within the containment by the VCS.

The VFS supply air subsystem airflow is measured and balanced in accordance with SMACNA-1993. The VFS containment isolation valves, which are located in auxiliary and containment building, conform to ASME Section III - Class 3 for Class B valves, and B31.1 for Class D valves.

The non-safety-related portions of the VFS are designed to accomplish their intended functions assuming a single active failure and a LOOP event. The VFS consists of two 100-percent capacity, 1.9 m^3/s (4000 cfm) supply and exhaust air subsystems. Each train consists of a supply AHU, ducted air supply, registers, valves and piping, automatic controls, and accessories. Each of the exhaust air systems consists of filtration units, exhaust fans, valves and piping, automatic controls, and accessories. Exhaust air subsystems also contain common containment isolation valves and piping prior to the inlet of the air filtration units and common exhaust leading to the plant vent. A gaseous radiation monitor, located downstream of the exhaust air filtration units in the common ductwork, activates an alarm in the MCR when excess activity in the effluent discharge is detected. The plant vent exhaust flow is monitored for gaseous, particulate, and iodine releases to the environment. The radiation monitoring is described in Section 11.5 of this report.

The supply AHUs are located in the south air handling equipment room of the annex building at Elevation 158'-0". The exhaust filtration units are located within the radiologically controlled portion of the annex building at Elevation 135'-3" and Elevation 146'-3". The common air intake plenum #3 for the supply and makeup air for the exhaust fan (which is not protected from turbine missiles) is located at the extreme south end of the annex building between Elevation 158'-0" and Elevation 180'-0". The ductwork located inside containment, the potential failure of which could affect safety-related equipment, is designed to seismic Category II. The VFS description, P&IDs, and component design parameters are provided in AP1000 DCD Tier 2 Section 9.4.7, Tables 3.2-3, 9.4-1, and 9.4.7-1 and Figure 9.4.7-1, respectively. Table 9.4-1 of this report describes the industry standards applicable to the components of the VFS.

Each supply AHU consists of a low-efficiency filter, a high-efficiency filter, a hot water heating coil with integral face and bypass dampers, a chilled water cooling coil, a supply air fan, and associated instrumentation and controls. The AHU air flow rate is controlled to a constant value

by modulating the supply fan inlet vanes to compensate for filter loading or changes in containment pressure. The discharged air through each AHU is controlled by temperature sensors located in the supply air duct. When the supply air temperature is low, the integral face and bypass dampers across the hot water heating coil bank are modulated to heat the supply air. When the supply air temperature is high, the chilled water flow is modulated to maintain the desired temperature in the area. The supply air is continuously monitored by a smoke alarm located in the common discharge ductwork downstream of the AHUs.

Each exhaust air filtration unit consists of a 100-percent capacity electric heater to maintain 70 percent or less RH of the effluent air, an upstream high-efficiency filter bank, a charcoal adsorber with pre- and post-HEPA filter bank, an exhaust fan, and instrumentation and controls. The post-filters downstream of the charcoal adsorbers have a DOP efficiency of 95 percent and conform to UL-900-1994, "Test Performance of Air Filter Units." The isolation dampers in the exhaust air subsystem are bubble-tight, single-blade or parallel-blade type, and conform to Air Movement and Control Association (AMCA) 500, "Testing Methods of Louvers, Dampers, and Shutters," and ASME AG-1-1997 and Addenda AG-1a-2000.

The representative samples of charcoal adsorbent are tested to verify a minimum charcoal efficiency of 90 percent, in accordance with the guidance of RG 1.140, Revision 2, at frequencies identified in the ASME N510-1989 standard. Each HEPA filter cell is individually shop tested to verify an efficiency of at least 99.97 percent in accordance with ASME AG-1-1997. The exhaust air subsystem filtration units are designed, constructed and tested to conform with ASME AG-1-1997, ASME N509-1989 and N510-1989 standards, and the guidelines of RG 1.140, Revision 2.

Each charcoal adsorber is a single-tray assembly with welded construction and a 101.6 mm (4 in) thickness Type III rechargeable adsorber cell, which conforms with IE Bulletin 80-03.

The air flow rate through the exhaust filters is controlled to a constant value when the exhaust filters are connected to the containment. This is accomplished by modulating the exhaust fan inlet vanes to compensate for filter loading or changes in system resistance caused by single or parallel fan operation, or a change in containment pressure. The containment exhaust line consists of isolation valves arranged in parallel, to restrict the airflow to maintain the exhaust plenum at a negative air pressure when the containment is positively pressurized. Therefore, the exfiltration of unfiltered air bypassing the filtration unit filters is prevented.

During normal plant operation, one supply AHU provides outdoor air, which is filtered, cooled or heated, to the containment areas above the operating floor. During single subsystem operation, the standby supply and exhaust air units can be started manually by the operator if the operating train fails. The supply of chilled water is provided from the VWS and hot water is provided from the VYS. The filtered exhaust air from the containment is discharged to the atmosphere through the plant vent by one exhaust fan.

Before and during cold plant shutdown, one or both trains of the VFS can be operated to remove airborne radioactivity before personnel access inside the containment. When both trains are in operation concurrently, the VFS provides a maximum air flow rate equivalent to 0.21 air changes per hour.

During an abnormal operation, if high airborne radioactivity or pressure differential is detected in the fuel-handling area, auxiliary or annex buildings (zone area(s)), the VAS is isolated from the served zone area(s) and the VFS exhaust air subsystem operates to maintain the isolated zone(s) at a slightly negative pressure with respect to adjacent clean areas. The exhaust airflow rate is modulated by differential pressure control dampers to provide outside makeup air to the exhaust fan when the VFS exhaust air subsystem is connected to the VAS-served zone area(s). The VFS is automatically isolated from the containment if purging is in progress and the standby exhaust filtration train does not start. One VFS train can be manually aligned to continue containment purging while the other VFS train is aligned to exhaust effluent from the zone areas. If both exhaust filtration trains are connected to containment, one exhaust filtration train is automatically isolated from the containment and is realigned to the zone area(s). The VFS exhaust air subsystem can be manually connected to the diesel generators during a LOOP. The VFS is not credited for a design basis FHA or a LOCA, but it may be used if it is operational and onsite power is available to support post-event recovery operations.

DCD Tier 2 Section 7.3 describes the VFS instrumentation. The VFS is controlled by the plant control system, except for the CIVs, which are controlled by the protection and safety monitoring system (PMS) and diverse actuation system (DAS). The instrumentation to satisfy Table 4-2 of ASME N509-1989 for the VFS air filtration units is discussed in DCD Tier 2 Section 9.7.1.5. The status indication and alarms are provided to monitor fans, control dampers and control valves. All fans and AHUs can be started remotely or shutdown from the MCR or locally. The temperature controllers maintain the proper supply air temperature.

The temperature indication and alarms for high or low supply air temperature are accessible locally via the plant control system to inform operators of abnormal temperature conditions for supply air and charcoal adsorbers. The flow indication and alarms are provided for equipment malfunctions. The radioactivity indication and alarms are provided in the MCR for the gaseous radioactivity in the filtration subsystem’s common exhaust duct and gaseous, and particulate and iodine concentrations in the plant vent. The pressure drops across all AHUs and exhaust air filtration unit filters (except charcoal filters) are monitored, and a high-pressure drop is alarmed in the MCR.

The safety-related portions (containment isolation) of the VFS are protected against internally and externally-generated missiles, as well as high- and moderate-energy pipe breaks, as discussed in Sections 3.5, 3.6, and 6.2.3 of this report.

The staff concludes that the system's safety-related portions comply with the guidelines of Regulatory Position C.1 of RG 1.29, and the system's non-safety-related portions comply with Regulatory Position C.2 of RG 1.29, on the basis of the following VFS design features:

- it is located inside the seismic Category I (containment and auxiliary building), flood-protected, and tornado-missile-protected buildings, and

- classification of the safety-related containment isolation valves, penetrations, interconnecting piping, debris screens, and vent and test connections as seismic Category I as shown in DCD Tier 2 Table 3.2-3.

System equipment and ductwork located in the nuclear island, the failure of which could affect the operability of safety-related systems or components, are designed to seismic Category II requirements to preclude them from collapsing onto safety-related equipment or structures during a SSE. The remaining portion of the system is non-seismic. In Section 3.7.3.13 of this report, the staff evaluated the VFS for interaction with seismic Category I systems and verified that its failure does not reduce the ability of any safety-related plant features to perform their functions. Therefore, the staff found that the system complies with the requirements of GDC 2.

The staff determined that the system is not an ESF system, and that it is not credited in analyzing the consequences of a DBA, except for containment isolation. Therefore, the requirements of GDC 4 and 17 are not applicable to this system.

As stated previously in Section 9.4 of this report, the HVAC design described in the DCD does not share SSCs with other nuclear power units. Therefore, the VFS meets the requirements of GDC 5.

The filtered VFS exhaust is monitored and then routed to the plant vent in compliance with the guidelines of RG 1.140, Revision 2 for controlling the release of radioactivity as described above. Therefore, the system complies with the requirements of GDC 60, as it relates to the system's capability to suitably control the release of gaseous radioactive effluent to the environment. The VFS filtration units, which also filter the VAS radioactive exhaust, meet the guidance of Regulatory Position C.4 of RG 1.13, which specifies that the spent fuel pool building be equipped with an appropriate ventilation and filtering system to limit the potential release of radioactive iodine and other radioactive materials. Therefore, the staff found that the system complies with the requirements of GDC 61, as it relates to the system capability to provide appropriate containment, confinement, and filtering to limit releases of airborne radioactivity to the environment.

The staff evaluated the VFS for conformance with GDC 2, 4, 5, 17, 60, and 61, as referenced in SRP Section 9.4.5 and concluded that the VFS meets the applicable GDCs. Therefore, the staff concludes that the VFS design is acceptable.

9.4.8 Radwaste Building HVAC System

The staff reviewed the VRS in accordance with SRP Section 9.4.3. Conformance with the SRP acceptance criteria forms the basis for concluding whether the VRS satisfies the following requirements:

- GDC 2, regarding the capability to withstand earthquakes,
- GDC 5, regarding sharing systems and components important to safety, and
- GDC 60, regarding the capability to suitably control release of gaseous radioactive effluent to the environment.

The VRS serves the radwaste building, which includes the clean electrical/mechanical equipment room, potentially contaminated HVAC equipment room, package waste storage room, waste accumulation room, and mobile system facility. The VRS is located within the

radwaste building, except for the portion that connects with the plant vent. The VRS is a non-seismic system and serves no safety-related functions. The VRS is a once-through, non-safety-related ventilation system that operates at 100 percent capacity continuously, with both supply air handling units and both exhaust fans on during normal plant operation to maintain suitable temperatures in the radwaste building. During filter replacement operations, the VRS operates at 50 percent capacity, and radwaste processing operations are adjusted to obtain an acceptable temperature in the radwaste building. The supply air system AHUs are located in the electrical/mechanical equipment room at Elevation 100'-0" on the southwest side of the radwaste building. The exhaust air system fans are located in the HVAC equipment room on Elevation 100'-0" in the northwest corner of the radwaste building.

The VRS collects the vented discharges from potentially contaminated equipment and provides for radiation monitoring of exhaust air before release to the environment through the plant vent stack. Radiation monitoring is described in Section 11.5 of this report.

The system description and components classification are provided in DCD Tier 2 Section 9.4.8, Figure 9.4.8-1, and Table 3.2-3. As identified in DCD Tier 2 Table 3.2-3, the VRS components are non-nuclear safety class, non-seismic category, and the quality assurance requirements of Appendix B to 10 CFR Part 50 do not apply. Table 9.4-1 of this report describes the industry standards applicable to the components of the VRS.

The VRS is designed to maintain proper operating temperatures in the following areas, depending on the maximum and minimum normal outside temperature conditions shown in DCD Tier 2 Chapter 2, Table 2-1 and summarized as follows:

- processing areas and storage rooms control between 10 °C and 40.5 °C (50 °F and 105 °F), and
- mechanical and electrical equipment rooms between 10 °C and 40.5 °C (50 °F and 105 °F).

The radwaste building is maintained at a negative pressure (with respect to ambient environment) to prevent (potentially) unmonitored radioactive releases from the radwaste building. The differential pressure controllers, with sensors located in the general building area and mounted outdoors (shielded from wind effects), automatically modulate the inlet vanes of the AHU supply fans to maintain negative pressure inside the radwaste building with respect to the outdoors. The electric interlocks between the large truck doors and the supply fan flow controller permit the supply air to drop to 2.832 m^3/s (6000 cfm) below the exhaust flow when any truck bay door is open to create a flow into the radwaste building through the open door.

The VRS consists of the supply air system and the exhaust air system. The VRS total flow is 8.495 m^3/s (18,000 cfm), consisting of two 4.248 m^3/s (9,000 cfm) trains. The supply air system consists of two 50-percent capacity AHUs, each with a low-efficiency filter bank, a high-efficiency filter bank, hot water heating coil, chilled water coil, and a centrifugal fan with automatic inlet vanes. The supply of chilled and hot water is provided from the VWS and VYS, respectively. Each AHU draws 100 percent outside air through individual louvered outdoor air intakes. The two AHUs discharge into a common air supply duct distribution system that is routed through the radwaste building.

The temperature of the air supplied by the AHUs is controlled by separate cooling and heating temperature controllers with sensors in the general building area. The cooling controllers modulate the control valves on the chilled water supply lines to the AHUs to maintain the desired temperature in the area. The heating controllers modulate the face and bypass dampers of the hot water heating coil in the AHUs to maintain the desired temperature in the area. The hot water unit heaters in the mobile facility, which are controlled by local thermostats, are provided to temper air entering the building when a roll-up door is opened. The hot water unit heater in the electrical/mechanical room operate in response to local thermostats to maintain the minimum required temperature.

The exhaust air system consists of two 50-percent capacity centrifugal fans sized to allow the system to maintain a negative pressure with respect to the adjacent areas, an exhaust air duct collection system, and automatic controls and accessories. The exhaust fans discharge to a common duct, which is routed to the plant vent. A radiation monitor records activity in the common exhaust air system discharge duct and activates an alarm in the MCR when excess activity in the effluent discharge is detected. The exhaust air collection duct inside the radwaste building exhausts air from areas and rooms where low levels of airborne contamination may be present. The exhaust connection points are provided to allow the direct exhaust of equipment located on the mobile systems. The back draft dampers are provided at each mobile system vent connection to prevent blowback through the equipment in the event of exhaust system trip. Where potential high levels of airborne radioactive contamination exist, mobile systems will include HEPA filtration. The mobile processing systems are discussed in DCD Tier 2 Section 11.2 and Section 11.4 of this report.

The VRS is designed to permit periodic inspection of system components during normal plant operation and is controlled by the PLS. (Refer to DCD Tier 2 Section 7.1.1 for a discussion of the PLS.) The temperature is indicated for each AHU supply air discharge duct. Local differential pressure indications and high-pressure alarms are provided for the AHU and exhaust air system air filters to alert the operator of the need for filter replacement. An alarm is provided for high radiation in the main exhaust duct to the vent stack. Airflow indications are provided for the AHU and exhaust fan discharge ducts, and low flow alarms are provided in the fan discharge ducts. The operational status indications for the fans are provided in the MCR. The fans and AHUs can be initiated or shutdown from the MCR. An alarm is provided for smoke in the common AHUs discharge duct. Position indicating lights are provided for automatic dampers. The VHS instrumentation is described in Section 7 of this report.

Regulatory Position C.1 of RG 1.29 does not apply because the VRS is not designed to perform any safety-related functions. The VRS complies with Regulatory Position C.2 of RG 1.29 as follows:

- The VRS serves no safety-related function. Failure of the system does not affect the operation of safety-related structures, systems, or components because none of these are located in the area served by the system.

- The system is non-safety-related and is not credited to operate during any abnormal plant conditions.

Therefore, the system complies with the requirements of GDC 2.

As stated previously in Section 9.4 of this report, the HVAC design described in the DCD does not share SSCs with other nuclear power units. Therefore, the VRS meets the requirements of GDC 5.

The VRS collects the vented discharges from potentially contaminated areas, and provides for radioactive particulate removal and radiation monitoring of exhaust air before release to the environment through the plant vent stack. Therefore, the system meets the requirements of GDC 60, as it relates to the system's capability to suitably control the release of gaseous radioactive effluent to the environment.

The staff evaluated the VRS for conformance with GDC 2, 5, and 60, as referenced in Section 9.4.3 of the SRP and concluded that these GDCs are met. Therefore, the staff concludes that the VRS design is acceptable.

9.4.9 Turbine Building Ventilation System

The staff reviewed the VTS in accordance with SRP Section 9.4.4, "Turbine Area Ventilation System." Conformance with the SRP acceptance criteria forms the basis for concluding whether the VTS satisfies the following requirements:

- GDC 2, "Design Bases Protection Against Natural Phenomena," regarding the capability to withstand earthquakes.

- GDC 5, "Sharing of Structures, Systems, and Components," regarding sharing systems and components important to safety.

- GDC 60, "Control of Releases of Radioactive Materials to the Environment," regarding the capability to suitably control release of gaseous radioactive effluent to the environment.

The VTS operates during startup, shutdown, and normal plant operations. The VTS consists of (1) the general area ventilation subsystem, (2) the electrical equipment and personnel work area HVAC subsystem, and (3) the local area heating and ventilation subsystem. The general area ventilation subsystem serves the operating deck, intermediate levels, and base slabs. The electrical equipment and personnel work area HVAC subsystem serves switchgear rooms 1 and 2, the electrical equipment room, the reactor coolant pump variable frequency drive (VFD) power converter room, and personnel work areas (secondary sampling laboratory and office spaces at Elevation 117'-6" and Elevation 171'-0") at Elevation 149'-0" and the engineering work station at Elevation 171'-0". The local area heating and ventilation subsystem serves the lube oil reservoir room, clean and dirty lube oil storage room, toilet areas (facilities), auxiliary boiler room, and motor-driven fire pump room. The VTS maintains the air temperature of all areas inside the turbine building between 10 °C and 40.6 °C (50 °F and 105 °F), except for the personnel work areas. These areas are maintained between 22.8 °C and 25.6 °C (73 °F and 78 °F), depending on the maximum and minimum normal outside temperature conditions shown in DCD Tier 2 Chapter 2, Table 2-1.

The system description and components classification are provided in DCD Tier 2 Section 9.4.9, Figure 9.4.9-1, and Table 3.2-3. As identified in DCD Tier 2 Table 3.2-3, the VTS

components are non-nuclear safety class, non-seismic category, and the quality assurance requirements of Appendix B to 10 CFR Part 50 do not apply. Table 9.4-1 of this report describes the industry standards applicable to the components of the VTS.

The VTS neither serves nor supports the plant’s safety-related functions; therefore, the system need not be designed to meet the guidelines of RGs 1.29 and 1.140 or to withstand the effects of a SSE. Some areas of the turbine building have a potential for radioactive contamination, but any contamination is expected to be low. Radiological monitors are provided in the turbine building to detect system leakage in the condenser air removal, steam generator blowdown, component cooling water, and main steam systems. The radiation monitoring system (RMS) is addressed in Sections 11.5 of this report.

The VTS is designed to permit periodic inspection of system components during normal plant operation. The VTS is monitored by the plant monitoring system, and controlled by the plant control system. Temperature indication is provided to allow temperature surveillance of room and space temperatures in the turbine building. Controllers are provided to control the room air temperatures to within a predetermined range. Differential pressure indication and high-pressure alarms are provided for the AHU air filters.

9.4.9.1 General Area Heating and Ventilation Subsystem

The general area ventilation subsystem serves most of the turbine building and is manually controlled. The subsystem consists of roof mounted exhaust ventilators and wall mounted louvers. The ventilators are hooded, direct driven, propeller type with pneumatically actuated back draft dampers. The wall louvers are located at Elevation 100’-0", Elevation 117’-6", and Elevation 135’-3". During heating operation, the general area ventilation subsystem is not operated. Additionally, the operating floor wall louvers are normally closed during power operation and are manually opened during outage operations for ventilation.

The general area heating subsystem is manually or automatically controlled. The system consists of hot water unit heaters and heater fans, and provides local heating throughout the turbine building. The system heater fan motors are controlled by thermostats in the automatic mode. The hot water is supplied from the VYS.

9.4.9.2 Electrical Equipment and Personnel Work Area HVAC Subsystem

This HVAC subsystem consists of an independent electrical equipment area HVAC system and an independent personnel work area HVAC system.

The subsystem chilled water is supplied from the VWS and hot water is supplied from the VYS. The subsystem maintains served areas at a slight positive pressure by mixing outside air with the recirculated air. The subsystem room thermostats control the chilled water control valves for cooling and the integral face/bypass dampers for heating.

Each independent system, serving corresponding areas, consists of two 50-percent AHUs located at Elevation 149’-0" of the turbine building. Each AHU consists of a mixing box section, high- and low- efficiency filters, integral face and bypass damper, a hot water heating coil, and chilled water cooling coil. The electrical equipment area HVAC system consists of two

50 percent capacity AHUs with a supply and return air of about 17,000 scfm each, a ducted supply and return air system, automatic controls, and accessories. The personnel work area HVAC system consists of two 50 percent capacity AHUs with a supply and return air of about 7,125 scfm each, a ducted supply and return air system, automatic controls, and accessories. Electric reheat coils are provided in the ductwork to each room served by the personnel work area HVAC system, to maintain close temperature control. During normal operation all AHUs operate continuously.

9.4.9.3 Local Area Heating and Ventilation Subsystem

The lube oil reservoir room, clean and dirty lube oil storage room, toilet areas (facilities), and secondary sampling laboratory fume hood have centrifugal exhaust fans to remove flammable vapors, odors, or chemical fumes as required.

A direct-drive, two-speed, wall exhaust ventilator is provided for each of the auxiliary boiler rooms, and the motor-driven fire pump room. The ventilators are two speed, propeller type with pneumatically actuated backdraft dampers. The air is pulled from the general area of the turbine building through the fire damper openings and exhausted to the atmosphere. Each exhaust ventilator is automatic or manually controlled. In the automatic mode, the exhaust ventilator motor is controlled by a two-stage room thermostat. In the manual mode, the exhaust fan runs continuously at high speed until it is stopped manually.

The motor driven fire pump room is heated by the hot water-to-unit heater supplied from the VYS for fire pump freeze protection. The hot water unit heater fan motors are controlled by a thermostat during automatic mode, or the heater fans run continuously in manual mode.

No hot water heating is provided in the auxiliary boiler room. The auxiliary boiler room exhaust fan pulls air from the general area of the turbine building. A heating thermostat is provided in the boiler room to control the operation of the fan when temperature falls below 10 °C (50 °F). The boiler room exhaust fan starts at low speed and continues to run until the space temperature rises above 10 °C (50 °F).

9.4.9.4 Conclusion

Compliance with Regulatory Position C.1 of RG 1.29 does not apply because the VTS is non-seismic and is not designed to perform any safety functions. The VTS complies with Regulatory Position C.2 of RG 1.29 as follows:

- The VTS serves no safety-related function. Failure of the system does not affect the operation of safety-related structures, systems, or components because none of these are located in the area served by the system.

- The system is non-safety-related and is not credited to operate during any abnormal plant conditions.

Therefore, the system complies with the requirements of GDC 2.

As stated previously in Section 9.4 of this report, the HVAC design described in the DCD does not share SSCs with other nuclear units. Therefore, the VTS meets the requirements of GDC 5.

As stated above, radiological monitoring is provided in the turbine building in the condenser air removal, steam generator blowdown system (BDS), CCS, and main steam systems to detect system leakage for any potential radioactive contamination. The RMS is addressed in Section 11.5 of this report. Also, provisions for temporary barriers are provided around the BDS, CCS, and condensate polishing areas for radiological protection. Therefore, the system is in compliance with the requirements of GDC 60.

As described above, the staff evaluated the VTS for conformance with GDC 2, 5, and 60, as referenced in SRP Section 9.4.4 and found that the VTS met these GDCs. Therefore, the staff concludes that the VTS design is acceptable.

9.4.10 Diesel Generator Building Heating and Ventilation System

The staff reviewed the VZS in accordance with SRP Section 9.4.5. Conformance with the SRP acceptance criteria forms the basis for concluding whether the VZS satisfies the following requirements:

- GDC 2, regarding the capability to withstand earthquakes.

- GDC 4, regarding maintaining environmental conditions in essential areas compatible with the design limits of the essential equipment located therein during normal, transient, and accident conditions.

- GDC 5, regarding sharing systems and components important to safety.

- GDC 17, regarding the assurance of proper functioning of essential electric power systems.

- GDC 60, regarding the capability to suitably control release of gaseous radioactive effluent to the environment.

The VZS serves the standby DG rooms, electric equipment service modules, and diesel fuel oil day tank vaults in the DG building, and the two diesel oil transfer modules located in the yard. The VZS consists of the normal heating and ventilation subsystem, the standby exhaust ventilation subsystem, the fuel oil day tank vault exhaust subsystem, and the diesel oil transfer module enclosures ventilation and heating subsystem.

As identified in DCD Tier 2 Table 3.2-3, the VZS components are a non-nuclear safety class and non-seismic category. As such, the quality assurance requirements of Appendix B of 10 CFR Part 50 do not apply. The system description and layout drawings are provided in DCD Tier 2 Section 9.4.10 and Figure 9.4.10-1, respectively. Table 9.4-1 of this report describes the industry standards applicable to the components of the VZS.

The two redundant DGs and associated equipment that provide standby ac power in the event of a LOOP are located in separate rooms of the non-safety-related DG building. Each DG room is served by an independent train of the VZS that provides normal heating and ventilation to continuously maintain acceptable environmental conditions in the area when the DGs are not operating. The standby exhaust ventilation portion of the VZS operates when the corresponding DG is in operation to maintain acceptable temperatures for equipment operation and reliability, in order for the onsite standby power system to perform its DID function. Within each DG room, an electrical equipment service module houses the DG electrical and control support equipment. Each DG has its own dedicated diesel oil transfer module with an enclosure and is located in the yard. The DGs are not safety-related and are not essential for the safe shutdown of the plant. The VZS, which supports the operation of the DGs, is also not safety-related.

The VZS is designed to maintain the temperature inside the DG area between 10 °C (50 °F) and 40.6 °C (105 °F) when the DG is not operating and a maximum of 54.4 °C (130 °F) when the DG is operating. In Section DCD Tier 2 8.3.1.1.2.1, the applicant states that the DGs will be procured to be consistent with the VZS (i.e., design requirement of a maximum of 54.4 °C (130 °F) when the DG is operating), as described in DCD Tier 2 Section 9.4.10.

The VZS also maintains the temperature inside the electrical equipment service modules between 10 °C (50 °F) and 40.6 °C (105 °F) at all times. Each dedicated diesel oil transfer module is maintained between 10 °C (50 °F) and 40.6 °C (105 °F) inside an enclosure. Two electric unit heaters are provided in each DG room, which maintains the space at 10 °C (50 °F) when the DGs are not operating. The VZS is designed for -20.6 °C to 35 °C (-5 °F to 95 °F) ambient conditions, which are the 5 percent exceedance values.

Each train of the normal heating and ventilation subsystem consists of one 100-percent capacity engine room AHU that ventilates the diesel generator room, one 100-percent capacity service module AHU that ventilates the electrical equipment service module, an exhaust system for the diesel generator room, an exhaust system for the fuel oil day tank vault, and two electric unit heaters in the DG area. The engine room AHUs are located above the electrical equipment service module with HVAC ducting in the DG rooms. The service module AHUs are located above the service module with HVAC ducting into the module. Outside air is supplied to each AHU through a wall-mounted fixed louver. Air intake louvers are located as high in the DG building wall as possible which meets the intent of the guidance of NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability," to control the dust and other particulates for conformance with GDC 17, as it relates to ensuring proper functioning of the standby onsite ac electric power system.

Each AHU of the normal heating and ventilation subsystem consists of a mixing box section, a high-efficiency filter bank, a low-efficiency filter bank, and a centrifugal fan. During normal plant operation, the engine room AHU runs continuously when the DG is off and outdoor air is required for room cooling. The space thermostats control the proportion of outside air that is mixed with return air to maintain adequate temperature in the engine room served areas. The excess outside air supplied to the engine room is discharged to the outdoors via a gravity relief damper.

Each service module AHU has an electrical heating coil that is controlled by a separate space thermostat. The outside air is supplied to each AHU through a wall-mounted fixed louver. The service module excess outside air flows into the diesel engine area via a wall-mounted relief damper. The service module AHU operates continuously regardless of the DG status.

Each train of the standby exhaust ventilation subsystem consists of two 50-percent capacity roof-mounted exhaust fans and two motor-operated air intake dampers mounted in the exterior walls of the room. The exhaust fans turn on when the DGs start and turn off when the DGs stop. The standby exhaust fans are actuated by a DG start signal, as shown in DCD Tier 2 Figures 9.4.10-1 and 9.4.10-2. The motor-operated air intake dampers open and close in conjunction with the operation of the exhaust fans. One or both standby exhaust fans are required to operate to maintain the engine room temperature in reference to ambient temperature. The subsystem is required to operate to support DG operation during LOOP.

Each fuel oil day tank vault is continuously ventilated by a 100-percent capacity centrifugal exhaust fan. The exhaust fans are roof mounted and ducted to draw air from 0.3 m (1 ft) above the vault floor to remove any oil fumes generated in the space. Air is drawn into each fuel oil tank vault from the DG room through a fire damper. The fans are manually operated.

The diesel oil transfer module enclosures are serviced by a separate exhaust ventilation system. Each diesel oil transfer module enclosure is ventilated by a 100-percent capacity roof-mounted exhaust fan. Outside air is drawn into the enclosure through manually operated louvered air intakes; these louvers are closed during winter operation when heating is required. An electric unit heater is provided in each enclosure to maintain the space at a minimum temperature of 10 °C (50 °F). The subsystem is required to operate to support DG operation during LOOP.

Because the VZS has two 50-percent capacity exhaust fans for each DG room and one 100-percent capacity AHU for each service module, at least one DG train will be fully operational should a single fan failure occur.

The system design allows for periodic inspection of the system's components. Refer to DCD Tier 2 Section 7.1.1 for the plant control system. The system temperature indication and alarms are accessible locally via the plant control system. The operational status indications for the fans are provided in the MCR. All fans and AHUs can be operable locally or from the MCR. Differential pressure indication for each filter in the AHUs and a high-pressure drop alarm for each AHU are provided.

Compliance with Regulatory Position C.1 of RG 1.29 does not apply because the VZS is not designed to perform any safety functions. The VZS complies with Regulatory Position C.2 of RG 1.29 as follows:

- The VZS serves no safety-related function. Failure of the system does not affect the operation of safety-related structures, systems, or components because none of these are located in the area served by the system.

- The system is non-safety-related and is not credited to operate during any abnormal plant conditions.

Therefore, the system design complies with the requirements of GDC 2 and is acceptable.

The VZS is not required to maintain a controlled environment in areas containing safety-related equipment, and areas served by the VZS do not contain equipment essential for the safe shutdown of the reactor or necessary to prevent or mitigate the consequences of a DBA. Therefore, GDC 4 is not applicable to the VZS.

As stated previously in Section 9.4 of this report, the HVAC design described in the DCD does not share SSCs with other nuclear power units. Therefore, the VZS meets the requirements of GDC 5.

The onsite standby power system (ZOS) includes two diesel generators housed in the non-safety-related DG building. The applicant states that the ZOS and DGs are not safety-related; therefore, they are not essential for the safe shutdown of the reactor, nor are they necessary to prevent or mitigate the consequences of a DBA. The applicant further states that the VZS is physically separated from potentially contaminated areas, and does not contain any radioactive materials. Therefore, compliance with the recommendations of RGs 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," and 1.140 and the requirements of GDC 60 are not required for the VZS.

The staff evaluated the VZS for conformance with GDC 2, 4, 5, 17, and 60, as referenced in SRP Section 9.4.5 and concluded that the VZS meets the applicable GDCs. Therefore, the staff concludes that the VZS design is acceptable.

9.4.11 Health Physics and Hot Machine Shop HVAC System

The staff reviewed the VHS in accordance with SRP Section 9.4.3. Conformance with the SRP acceptance criteria forms the basis for concluding whether the VHS satisfies the following requirements:

- GDC 2, regarding the capability to withstand earthquakes.
- GDC 5, regarding sharing systems and components important to safety.
- GDC 60, regarding the capability to suitably control release of gaseous radioactive effluent to the environment.

The VHS collects the vented discharges from potentially contaminated sumps and equipment in the health physics area, as well as exhaust from welding booths, grinders, and other equipment located in the hot machine shop. It also monitors exhaust air for radiation before its release to the environment through the plant vent stack. The radiation monitoring is described in Section 11.5 of this report.

The VHS serves no plant safety-related functions and there are no safety-related structures, systems, or components in the area serviced by the system. The VHS is a once-through, non-safety-related ventilation system that operates only during normal modes of plant operation. The VHS is located within the annex building, except for the portion that connects

with the plant vent. The VHS serves both the health physics/access control area in the annex building located at Elevation 100’-0" and the hot machine shop located at Elevation 107’-2" in the annex building. These areas are maintained at a slight negative pressure with respect to the outdoors and clean areas to ensure that all potentially radioactive releases are monitored before discharge.

The supply air subsystem AHUs are located in the lower south air handling equipment room on Elevation 135’-3" of the annex building, and the exhaust air subsystem fans are located in the staging and storage areas on Elevation 135’-3" of the annex building.

As identified in AP1000 DCD Tier 2 Table 3.2-3, the VHS components are non-nuclear safety class, non-seismic category, and the quality assurance requirements of 10 CFR Part 50, Appendix B do not apply. The system description and layout drawings are provided in DCD Tier 2 Section 9.4.11 and Figure 9.4.11-1, respectively. Table 9.4-1 of this report describes the industry standards applicable to the components of the VHS.

The VHS maintains the direction of air flow from areas of low potential radioactivity to areas of higher potential radioactivity. The VHS is designed to maintain the temperature of the health physics area at 22.8 to 25.6 °C (73 to 78 °F), and the hot machine shop at 18.3 to 29.4 °C (65 to 85 °F), depending on the maximum and minimum normal outside temperature conditions shown in DCD Tier 2 Chapter 2, Table 2-1. The VHS is designed to maintain a minimum RH of 35 percent in normally occupied areas via a steam humidifier located in the main system supply duct. The water for the system humidifier is provided by the demineralized water system.

The differential pressure controllers, with sensors in the general health physics area and sensors mounted outdoors (shielded from wind effects), modulate the automatic inlet vanes of the supply fan to maintain the area at a negative pressure with respect to the surrounding areas. A separate differential pressure controller, with a sensor in the hot machine shop, modulates a damper in the supply air duct to the hot machine shop to maintain a negative pressure with respect to the outdoors which do not have their exhausts monitored for radioactivity.

The VHS consists of the supply air subsystem and the exhaust air subsystem. The supply air subsystem consists of two 100-percent capacity (14,000 scfm each) AHUs, each with a low-efficiency filter bank and a high-efficiency filter bank; hot water heating coil; chilled water cooling coil bank, a centrifugal fan with automatic inlet vanes, associated dampers, instrumentation, and controls; and ductwork. Each AHU draws 100 percent outside air through a common louvered outdoor air intake plenum #2, as described in DCD Tier 2 Section 9.4.2. The two AHUs discharge into a distribution system to the health physics and hot machine shop areas. The temperature in the health physics and hot machine shop areas are maintained within the design range by a temperature sensor located in the health physics area. This sensor modulates the control valve on the chilled water supply lines to the cooling coil and the face and bypass dampers of the hot water heating coil. The supply of the chilled and hot water is provided from the VWS and VYS, respectively.

The exhaust air subsystem consists of two 100-percent capacity centrifugal exhaust fans, sized to maintain a negative pressure with respect to the adjacent areas, with ductwork and automatic controls. A separate machine shop exhaust fan and high-efficiency filter are provided for

exhausting from machine tools and other localized areas in the hot machine shop. The air flow rates are balanced to maintain a constant exhaust air flow across the fans. The exhaust fans discharge to a common duct, which is routed to the plant vent stack. Individual flexible exhaust duct branches are provided to machine tools. The flexible ducts are connected to a hard duct manifold, which is connected to a filter and a fan. The exhaust fan discharges into the main system exhaust ductwork.

One supply AHU and one exhaust fan are capable of maintaining corresponding areas at the designed temperatures, at a slight negative pressure, and with the direction of system air flow from areas of low radioactivity to areas of high radioactivity, should a single fan failure occur.

The health physics area, including the hot machine shop, is monitored by a non-safety-related radiation monitor. The radiation monitor is located in the common VHS exhaust duct. High-radiation alarms are provided both locally and in the MCR. DCD Tier 2 Sections 9.4.11 and 11.5, and Tables 11.5-1 and 11.5-2 describe these radiation monitors.

Temperature indication is provided for each AHU supply air discharge duct. Local differential pressure indications and MCR high-pressure alarms are provided for the AHU and exhaust air system air filters. The remote manual hand switches and alarms for the system fans are provided in the MCR. The fans and AHUs can be initiated or shutdown from the MCR. An alarm is provided for smoke in the common AHUs discharge duct. Position indicating lights are provided for automatic dampers.

Regulatory Position C.1 of RG 1.29 does not apply because the VHS is not designed to perform any safety functions. The VHS complies with Regulatory Position C.2 of RG 1.29 as follows:

- The VHS serves no safety-related function. Failure of the system does not affect the operation of safety-related structures, systems, or components because none of these are located in the area served by the system.

- The system is non-safety-related and is not credited to operate during any abnormal plant conditions.

Therefore, the system design complies with the requirements of GDC 2 and is acceptable.

As stated previously in Section 9.4 of this report, the HVAC design described in the DCD does not share SSCs with other nuclear power units. Therefore, the VHS meets the requirements of GDC 5.

The VHS is not safety-related, performs no safety-related function for safe-shutdown or post-accident operation, and failure of the system does not affect the function of other safety-related equipment. The annex building lower south air handling equipment room, where VHS supply AHUs are located, has no sources of radioactivity during normal plant operation. The hot machine shop mezzanine area, where hot machine shop exhaust fans are located, is not a high-radioactivity area. The shielding of components and personnel is commensurate with radiation sources in the vicinity of the VHS equipment during normal plant operation.

The VHS collects the vented discharges from potentially contaminated areas and provides for radiation monitoring of exhaust air prior to release to the environment through the plant vent stack. Therefore, the requirements of GDC 60 are met.

The staff evaluated the VHS for conformance with GDC 2, 5, and 60, as referenced in SRP Section 9.4.3, and concluded that the VHS meets GDC 2, 5, and 60. Therefore, the staff concludes that the VHS design is acceptable.

Table 9.4-1 HVAC System Components

Component	Standard	Title
Supply, return, and exhaust fans	ANSI/AMCA 210-85	Laboratory Methods of Testing Fans for Rating Purposes
	ANSI/AMCA 211-87	Certified Ratings Program Air Performance
	AMCA 300-85	Reverberant Room Method of Testing Fans for Rating Purposes, Standards
Housings, Ductwork, supports, and accessories	SMACNA-1980	Rectangular industrial Duct Construction Standards
	SMACNA-1995	HVAC Duct Construction Standards - Metal and Flexible
	SMACNA-1999	Round industrial Duct Construction Standards
	SMACNA 1985	HVAC Duct Leakage Test Manual
	Addenda AG-1a-2000	Housings
Low efficiency filters, high-efficiency filters, and post-filters	ASHRAE 52.1, 1992	Gravimetric and Dust Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter, Standards
	ASHRAE 126, 2000	Method of Testing HVAC Air Ducts
	ASHRAE 62-1999	Ventilation for Acceptable Indoor Air Quality
	UL 900, 1994	Test Performance of Air-Filter Units, Class I Criteria
Cooling coils and hot water heating coils	ANSI/ARI 410-91	Forced Circulation Air Cooling and Air Heating Coils
	ASHRAE 33-78	Methods of Testing for Rating Forced Circulation Air Cooling and Air Heating Coils
Electric unit heaters	UL-1996, 1996	Electric Duct Heaters
	NFPA 70, 1999	National Electrical Code
Electric heating coils	UL1095, 1995	Electric Central Air Heating Equipment
Humidifiers	ARI 620-96	Self-Contained Humidifiers, Standards
Dampers, Isolation Dampers, and Containment Exhaust Air Dampers	ANSI/AMCA 500-89	Testing Methods for Louvers, Dampers, and Shutters, Standards
	SMACNA-1993	HVAC Systems - Testing, Adjusting, and Balancing
	ASME N509-1989	Nuclear Power Plant Air-Cleaning Units Components

Component	Standard	Title
HEPA filters and Charcoal Adsorbers	ASME N510-1989	Testing Nuclear Air Cleaning Systems
	ASME N509-1989	Nuclear Power Plant Air-Cleaning Units Components
	ASME/ANSI AG-1-1997	Code on Nuclear Air and Gas Treatment
	UL-586, 1996	High-Efficiency, Particular, Air-Filter Units
Smoke and fire dampers	UL-555, 1999	Fire Dampers
	UL-555S, 1999	Leakage Rated Dampers for Use in Smoke Control Systems
	NFPA 90A-1999	Installation of Air Conditioning and Ventilation Systems

9.5 Other Auxiliary Systems

9.5.1 Fire Protection Program

The fire protection (FP) system detects and suppresses fires, and is an integral part of the AP1000 FP program. The FP review criteria for the AP1000 are specified in SECY-90-016, "Evolutionary Light Water Reactor (LWR) Certification Issues And Their Relationship To Current Regulatory Requirements," SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advance Light Water Reactor (ALWR) Designs," and SECY-94-084, "Policy And Technical Issues Associated With The Regulatory Treatment Of Non-Safety Systems In Passive Plant Designs." In addition, 10 CFR 52.48 specifies that the design will comply with the requirements specified in 10 CFR 50.48, "Fire protection," and GDC 3, "Fire protection." Conformance with the SRP is addressed in 10 CFR 50.34(g), which specifies that applications include an evaluation of the facility against the SRP. The FP guidance for nuclear power plants (NPPs) specified in the SRP is provided in BTP Chemical Engineering Branch (CMEB) 9.5-1 "Guidelines for Fire Protection for Nuclear Power Plants."

In addition to the guidance specified in the BTP, the staff specified in SECY-90-016, SECY-93-087, and Section 9.3 of NUREG-1242, "NRC Review of Electric Power Research Institute's Advanced Light Water Reactor Utility Requirements Document," Volume 3, that the ALWRs should provide an enhanced level of FP to ensure that safe shutdown can be achieved assuming all equipment in any one fire area is rendered inoperative as a result of fire damage, and that reentry into the fire area by plant personnel for repairs or operator actions is not possible. The control room and the containment are excluded from this criterion, provided an independent alternative shutdown capability is provided for a control room fire, and that FP for redundant divisions located inside containment is provided to ensure that one shutdown division will be free of fire damage following a fire inside the containment.

The design should also ensure that smoke, hot gases, and fire suppressants do not migrate into other fire areas to the extent that they could adversely affect safe-shutdown capabilities, including operator actions. In response to RAI 280.009, the applicant confirmed that when a fire was postulated in a fire area, all components in the fire area are assumed to be inoperable, whether this results from fire or smoke damage. All components in the neighboring area were also assumed to be inoperable due to fire or smoke damage.

The NRC staff interpretations and positions, discussed above, related to FP which are published in generic communications were used as applicable in the review of the AP1000. In addition, the latest applicable NFPA codes, standards and recommended practices were applied to the FP systems and features provided in the AP1000 design. To support the AP1000 Design Certification, WCAP-15871, "AP1000 Assessment Against NFPA 804" was also submitted to the staff and provides a comparison of the AP1000 design to the 2001 Edition of NFPA 804, "Fire Protection For Advanced Light Water Reactor Electric Generating Plants." In response to RAI 280.003, the applicant revised the DCD and WCAP-15871 in accordance with SECY 93-087, to ensure that the AP1000 design applied the latest industry standards endorsed by the NRC in RG 1.189, "Fire Protection for Operating Nuclear Power Plants."

DCD Tier 2 Section 9.5.1, "Fire Protection System" states that the primary objectives of the AP1000 FP program are to prevent fires and to minimize the consequences should a fire occur. In DCD Tier 2 Table 9.5.1-1, the applicant provided a point-by-point comparison of the conformance of the FP program with the BTP. In addition, the FP program provides protection so that the plant can be shut down safely following a fire. The AP1000 was reviewed for compliance with BTP CMEB 9.5-1.

The following evaluation is based on the staff's review of DCD Tier 2 Chapter 9 and Appendix 9A. All of the COL action items and deviations from BTP CMEB 9.5-1 identified and approved for the AP1000 FP program were also approved for the AP600 FP program. No new COL action items were identified for the AP1000 design. A summary of all the approved deviations and COL action items are shown in Section 9.5.1.9 of this report.

9.5.1.1 Fire Protection Program Requirements

9.5.1.1.a Fire Protection Program (Regulatory Position C.1.a of BTP CMEB 9.5-1)

The establishment of a FP program at the facility for the protection of structures, systems, and components important to safety, and the procedures, equipment and personnel required to implement the program is the responsibility of the COL applicant. This is COL Action Item 9.5.1-1(a).

9.5.1.1.b Fire Hazard Analysis (Regulatory Position C.1.b of BTP CMEB 9.5-1)

The applicant has provided the fire hazard analysis for the AP1000 design in DCD Tier 2 Section 9.5.1 and Appendix 9A. This analysis demonstrates that the plant will maintain the ability to perform safe shutdown functions, minimize radioactive releases to the environment, identify fire hazards and appropriate protection, and verify that NRC FP guidelines (e.g., BTP CMEB 9.5-1, SRP etc.) have been met. In RAI 280.007, the staff asked the applicant to resolve a discrepancy in Section 2.4 of WCAP-15871, which indicated that an analysis of the potential effects of a fire on the release of contamination had not been included. The applicant indicated in their response that WCAP-15871 would be revised to reflect that the design was appropriately evaluated, as already stated in DCD Tier 2 Section 3.11 and Item 12 of Table 9.5.1-1. The applicant issued a revision to WCAP-15871 in December 2002 which incorporated the staff's concerns. The revision of the fire hazard analysis to reflect the actual plant configuration is the responsibility of the COL applicant. This is COL Action Item 9.5.1-2.

The staff has determined that the design commitments in the following figures of DCD Tier 2 Section 9.5.1, Appendix 9A, Fire Protection Analysis, if considered for a change by a COL applicant or licensee will require NRC review and approval prior to implementation of the change. The commitment identified below should be listed in the proposed rule certifying the AP1000 design as Tier 2* information.

AP1000 DCD	DESCRIPTION
Figure 9A-1	Nuclear Island Fire Area Plan
Figure 9A-2	Turbine Building Fire Area Plan
Figure 9A-3	Annex I & II Building Fire Area Plan
Figure 9A-4	Radwaste Building Fire Area Plan
Figure 9A-5	Diesel Generator Building Fire Area Plan

9.5.1.1.c Fire Suppression System Design Basis (Regulatory Position C.1.c of BTP CMEB 9.5-1)

The fire suppression systems located inside the containment and outlying buildings are subject to a single active failure or crack that could impair both the primary and backup fire suppression capabilities. This is not in accordance with the guidance specified in the BTP CMEB 9.5-1. The fire suppression systems located inside the containment are qualified to seismic Category I criteria, which reduces the potential for a failure of the system. The buildings outside containment do not contain safety-related equipment, or present an exposure hazard to structures containing safety-related equipment. Manual fire suppression capability using hose lines connected to the outside hydrants of the yard main can be provided in the event of a failure of the interior fire suppression systems. On the basis of the seismic qualification of the fire suppression system located inside containment, the finding that there is no safety-related equipment in the outlying buildings, and that there is manual suppression capability using the outside hydrants, the staff concludes that this alternative means of protection is acceptable.

The staff also concludes that the applicant identified no other exceptions from the guidance specified in the BTP CMEB 9.5-1 related to fire suppression system design basis and is, therefore, acceptable. This is Deviation 9.5.1-1.

9.5.1.1.d Alternative/Dedicated Shutdown (Regulatory Position C.1.d of BTP CMEB 9.5-1)

The staff identified in RAI 280.004 that Items 75 and 76 of DCD Tier 2 Table 9.5.1-1 stated that alternative or dedicated shutdown capability were not necessary. These statements were incorrect and inconsistent with the staff’s position in BTP CMEB 9.5-1 on alternative/dedicated shutdown. Therefore, the applicant revised the information in Table 9.5.1-1 to remain consistent with the NRC staff’s alternative/dedicated shutdown position developed for AP1000. The staff has determined that the applicant has remained consistent with this staff position as identified in DCD Tier 2 Chapter 9 and Table 9.5.1-1.

9.5.1.1.e Implementation of Fire Protection Program (Regulatory Position C.1.e of BTP CMEB 9.5-1)

The implementation of the FP program prior to receiving fuel onsite for fuel storage areas, and for the entire unit prior to reactor startup is the responsibility of the COL applicant. This is COL Action Item 9.5.1-1(b).

9.5.1.2 Administrative Controls (Regulatory Position C.2 of BTP CMEB 9.5-1)

The establishment of administrative controls to maintain the performance of the FP systems and personnel is the responsibility of the COL applicant. This is COL Action Item 9.5.1-1(c).

9.5.1.3 Fire Brigade (Regulatory Position C.3 of BTP CMEB 9.5-1)

The establishment of a site fire brigade trained and equipped for fire fighting to ensure adequate manual fire fighting capability for all plant areas containing structures, systems, or components important to safety is the responsibility of the COL applicant. This is COL Action Item 9.5.1-1(d).

9.5.1.4 Quality Assurance Program (Regulatory Position C.4 of BTP CMEB 9.5-1)

The establishment of a quality assurance program to ensure that the guidelines for the design, procurement, installation, and testing, as well as the administrative controls for FP systems are satisfied is the responsibility of the COL applicant. This is COL Action Item 9.5.1-1(e).

9.5.1.5 General Plant Guidelines (Regulatory Position C.5 of BTP CMEB 9.5-1)

9.5.1.5.a Building Design (Regulatory Position C.5.a of BTP CMEB 9.5-1)

The safety-related structures, the containment and auxiliary building NRCAs, are separated from non-safety-related structures, the turbine building, annex building, radwaste building, diesel generator building, and auxiliary building (RCAs), by barriers having a minimum fire resistance rating of three hours. With the exception of the control room, the remote shutdown workstation, and the containment, fire barriers with a minimum fire resistance rating of three hours are provided to separate redundant divisions of the passive safety-related systems.

Openings through fire barriers for pipe conduit and cable trays are sealed with noncombustible materials to provide a fire resistance rating equal to that required by the barrier, qualified in accordance with the criteria specified in the BTP CMEB 9.5-1. Penetrations for ventilation systems are protected in accordance with the criteria specified in NFPA 90A. Doors installed in fire barriers are qualified in accordance with the criteria specified in NFPA 80, "Fire Doors and Fire Windows." Inspection and maintenance of fire doors, access to keys for the fire brigade, and the marking of exit routes is the responsibility of the COL applicant. This is COL Action Item 9.5.1-1(f).

The use of gypsum wallboard, which the applicant proposed to install in lieu of concrete, to enclose personnel access and egress routes which meet the criteria of BTP CMEB 9.5-1 is

currently unresolved. A more detailed discussion of this open item is provided in further detail in Section 9.5.1.9 to this report.

There are no cable spreading rooms in the AP1000 design. Therefore, the guidance specified in BTP CMEB 9.5-1 addressing separation of cable spreading rooms is not applicable. In addition, gaseous suppression systems are not used in the AP1000 design. Therefore, the guidance specified in BTP CMEB 9.5-1 addressing gaseous suppression systems is not applicable.

Interior finish, wall, ceiling, structural components, thermal insulation, radiation shielding, and soundproofing materials used in the AP1000 are noncombustible. Metal deck roof construction is noncombustible and listed as Class I in the Factory Mutual Research Corporation (FMRC) Approval Guide, "Equipment, Materials, Services for Conservation of Property."

The cables used in the plant are qualified in accordance with the criteria specified in IEEE 1202, "Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies." During the review of AP600, the staff approved the use of the 10" wide ribbon burner specified in IEEE-383, "IEEE Standard for Type Test of Class IE Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations," and IEEE 1202 as the only acceptable test procedure. The applicant verified in their response to RAI 280.002 that their intent was to remain consistent with the AP600 design and use only the 25.4 cm (10in) wide ribbon burner cable for AP1000. The use of the 25.4 cm (10in) wide ribbon burner for testing cable for the Ap1000 design is acceptable because it is in accordance with IEEE-383.

With the exception of the combustible cable insulation installed in the underfloor and ceiling spaces in the control room, technical support center and remote shutdown workstation, the concealed spaces are free of combustible materials. BTP CMEB 9.5-1 specifies that concealed spaces should be devoid of combustibles. Fire detection is provided in the concealed areas containing cables. The alternative protection provides an equivalent level of safety as that specified in BTP CMEB 9.5-1 and is, therefore, acceptable. This is Deviation 9.5.1-2.

Transformers installed in safety-related areas are either dry type or contain a noncombustible liquid. Outdoor transformers are located at least 15.2 m (50 ft) from other structures or are separated by blank fire walls with a minimum fire resistance rating of three hours. Outdoor oil-filled transformers are provided with oil containment or drainage away from structures.

Floor drains of adequate capacity are provided in areas containing safety-related equipment to remove fire suppression water discharged from fixed or manual fire suppression systems. The collection and sampling of water drainage from areas that may contain radioactivity is the responsibility of the COL applicant. This is COL Action Item 9.5.1-1(g).

Drains installed in areas containing combustible liquids are equipped with backflow prevention to preclude the flow of combustible liquids into areas containing safety-related equipment.

The applicant identified two exceptions from the guidance specified in BTP CMEB 9.5-1. The first exception is the cable insulation installed in the concealed spaces of the MCR, TSC, and remote shutdown workstation. This exception is acceptable because fire protection is provided in the concealed areas containing cables. The second exception is in regards to the use of

gypsum stair towers which is Open Item 9.5.1-1 in Section 9.5.1.9 of this report. Pending resolution of Open Item 9.5.1-1, the staff finds the design acceptable.

9.5.1.5.b Safe Shutdown Capability and 9.5.1.5.c Alternative or Dedicated Shutdown Capability (Regulatory Positions C.5.b and C.5.c of BTP CMEB 9.5-1)

The AP1000 criteria for the protection of safe and cold shutdown capability, following a single fire in any fire area, are as follows:

- Safe shutdown following a fire is defined for the AP1000 as the ability to achieve and maintain the RCS temperature below 215.6 °C (420 °F) without venting of the primary coolant from the RCS. This is a departure from the BTP CMEB 9.5-1 criteria applied to the evolutionary plant designs, and the existing plants, where safe shutdown for fires applies to both hot and cold shutdown capability. This is consistent with SECY-94-084, and is therefore acceptable. This is Deviation 9.5.1-3.

- Cold shutdown for the AP1000 is defined as the ability to achieve and maintain the RCS below 93.3 °C (200 °F), consistent with the criteria applicable to the evolutionary designs and existing plants and is acceptable.

The use of the non-safety-related normal shutdown systems and/or the safety-related passive systems are acceptable to the staff to achieve and maintain safe shutdown following a fire. The safety-related passive systems are considered an alternate/dedicated shutdown method as described in BTP CMEB 9.5-1 for fire areas where the normal shutdown systems have not been protected in accordance with the guidance prescribed in BTP CMEB 9.5-1. Consistent with the FP criteria for the advance light-water reactors specified in SECY-90-016 and SECY-93-087, redundant divisions of these systems shall be separated, such that a fire in any fire area outside of the containment or the MCR will not impair the plant's capability to achieve and maintain safe shutdown as defined above, assuming a loss of all equipment in the affected fire area.

Consideration in the safe shutdown analysis of personnel entry into the affected fire area to repair or operate equipment, to achieve safe shutdown, is prohibited, consistent with SECY-90-16. Personnel entry into the affected fire area to repair or operate equipment necessary to achieve and maintain cold shutdown of the AP1000 is acceptable, as a result of the unique capability of the AP1000 to remain in safe shutdown using only passive systems for an extended period of time.

The criteria in BTP CMEB 9.5-1, concerning cold shutdown capability, deviates from the criteria (in SECY 93-087, SECY 94-084, and SECY 90-016) applied to the evolutionary reactor designs, but is consistent with the criteria applicable to existing plants. To enhance the survivability of the normal safe shutdown and cold shutdown capability in the event of a fire, and to reduce the reliance on the infrequently utilized safety-related passive systems, automatic suppression shall be provided in those fire areas outside containment where a fire could damage the normal shutdown capability, or result in a spurious operation of equipment that could result in a venting of the RCS. This criterion is unique AP1000 advanced reactor designs and does not ensure that the normal shutdown capability will be free of fire damage, or that the equipment necessary to achieve and maintain cold shutdown can be repaired within 72 hours. This is consistent with SECY-94-084, and is therefore acceptable because the design utilizes

passive safety-related systems as the alternative dedicated safe shutdown. This is Deviation 9.5.1-4.

As a result of the inability of the fire brigade to rapidly enter the AP1000 containment in the event of a fire, and the potential for damage to safety-related and normal shutdown equipment, in addition to potential spurious actuation(s) resulting in a venting of primary coolant from the RCS, the protection of circuits and equipment inside containment should be enhanced beyond the criteria specified in BTP CMEB 9.5.1 for existing plants, consistent with the staff’s technical position stated in Section 9.3 of NUREG-1242.

The applicant provided adequate suppression and detection of the equipment and circuits located inside containment that are required for safe shutdown. This provides reasonable assurance that one division of safety-related equipment will remain free of fire damage, in accordance with the criteria specified above in NUREG-1242. Complete fire barrier separation cannot be provided inside of containment due to the need to maintain the free exchange of gases, for purposes such as passive containment cooling. The location of safety-related equipment and routing of Class IE electrical cable in separate fire zones, enhances the separation of redundant safe shutdown components.

Hose stations for manual suppression are provided inside containment; however, because of the potential hazard associated with personnel entry into containment during a plant transient, the response of the plant fire brigade may be significantly delayed. Therefore, no credit for manual suppression of fires inside containment during power operations is considered acceptable by the staff.

In fire zone 1100 AF 11300B, the applicant provided a manually actuated water spray system over the non-safety-related open cable trays in this zone to limit smoke and heat generation. Both divisions of the passive residual heat removal (PRHR) control valves and PRHR flow transmitters are located in this zone in close proximity to each other. These valves are separated by a noncombustible steel or steel composite barrier. Separate fire detectors are provided near each valve. There are no exposed cables in fire zone 1100 AF 11300A, which is adjacent to fire zone 1100 AF 11300B. The applicant has provided reasonable assurance that one division of the normal or passive safe shutdown capability located inside containment will be maintained free of fire damage; therefore, this aspect of the design is acceptable.

The applicant included the reactor head vents for consideration as a high/low pressure interface, in accordance with the guidance provided in Generic Letter 81-12, "Fire Protection Rule." Inside containment, the cables for the control of one head vent valve in each flow path are routed in separate conduits to prevent a spurious actuation of both valves in the flow path. In areas outside containment (the MCR and the remote shutdown workstation) the power and control circuits are located in separate fire areas. The soft controls located in the MCR and remote work stations are not susceptible to fire induced spurious actuation. The dedicated switches located in the MCR are located on separate panels, such that a fire may short the switches on one panel, but the unaffected panel will be deenergized before spurious actuation of two valves in the same flow path.

Spurious actuation of the automatic depressurization system (ADS), resulting from hot shorts of control circuits of motor operated valves from a fire in the MCR, remote shutdown workstation,

DC equipment rooms, and Class 1E penetration rooms, were addressed by the applicant. Separation and prompt operator actions are credited to minimize the potential for spurious actuation of the ADS. The spurious actuation of the ADS does not result in an unrecoverable plant configuration or prevent safe shutdown. As stated in the applicant's response to RAI 280.010, spurious actuations of passive safety systems, other than ADS, due to fire and potential spurious actuations of non-safety systems due to fire, were also considered in the AP1000 design as documented in DCD Tier 2 Section 9A.3.7.1.2. By design of the AP1000, no spurious actuation of a non-safety system would defeat the passive safety systems. The staff has concluded, based on the above review, that the safe shutdown capability and the alternative dedicated shutdown capabilities are acceptable.

9.5.1.5.d Control of Combustibles (Regulatory Position C.5.d of BTP CMEB 9.5-1)

Safety-related systems are separated from concentrations of combustible materials where practical. Where separation is not possible, appropriate FP based on the fire hazard analysis is provided. BTP CMEB 9.5-1 specifies that bulk gas storage tanks should not be located inside structures containing safety-related equipment. However, breathing air storage tanks for the AP1000 design are located in the auxiliary building NRCA. These tanks are safety-related and are provided with over pressure protection and are, therefore, acceptable. This is Deviation 9.5.1-5. High-pressure gas storage containers are located in accordance with the guidance prescribed in BTP CMEB 9.5-1.

The control of the use of compressed gases inside structures is the responsibility of the COL applicant. This is COL Action Item 9.5.1-1(h).

The use of plastic materials in the plant is minimized through design and administrative controls. The storage of flammable liquids complies with the criteria specified in NFPA 30, "Flammable and Combustible Liquids Code," referenced in BTP CMEB 9.5-1 and RG 1.189.

Hydrogen lines in safety-related areas are designed to seismic Category 1 requirements. The design of the plant hydrogen system complies with the criteria specified in NFPA 50A, "Standard for Gaseous Hydrogen Systems at Consumer Sites," referenced in BTP CMEB 9.5-1 and RG 1.189.

With the exception of the breathing air storage tanks for the MCR, the applicant identified no exceptions from the guidance specified in BTP CMEB 9.5-1. The staff finds that with this exception, the applicant meets BTP CMEB 9.5-1, and is, therefore, acceptable.

9.5.1.5.e Cable Construction (Regulatory Position C.5.e of BTP CMEB 9.5-1)

Cable trays, conduit, and other electrical raceways are constructed of noncombustible and metallic materials in accordance with the criteria specified in BTP CMEB 9.5-1. Electrical raceways are only used for cables.

Safety-related cable trays located outside of containment are separated from redundant divisions and non-safety-related areas by three-hour fire rated barriers. Cable trays located inside containment, containing safety-related cables, are enclosed in noncombustible steel or steel composite materials. Safety-related cable trays are provided with line-type heat detection

and are designed to allow wetting with fire suppression water without causing electrical faults. With the exception of the containment, safety-related cable trays are accessible for manual firefighting. In fire zone 1100 AF 11300B, the applicant provided a manually actuated water spray system over the non-safety-related open cable trays in this zone.

Electrical cable is qualified in accordance with the criteria specified in IEEE 1202, "Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies." Miscellaneous storage and piping for combustible liquids or gases are located so as to not present an exposure hazard to safety-related systems. In accordance with BTP CMEB 9.5-1, the applicant provided reasonable assurance that one division of the safety-related cables will remain free of fire damage. Therefore, the staff finds this aspect of the design acceptable.

9.5.1.5.f Ventilation (Regulatory Position C.5.f of BTP CMEB 9.5-1)

In accordance with BTP CMEB 9.5-1, the ventilation system is designed such that smoke and other products of combustion following a fire can be discharged to an area that will not affect safety-related equipment.

Ventilation for the containment/shield building is discussed in DCD Tier 2 Section 9A.3.1.1. Smoke control for this area consists of VFS containment isolation valves. If open, they are closed by operator action to control the spread of fire and smoke. After the fire, smoke is removed from the fire area by portable exhaust fans and flexible ductwork.

Smoke control for the NRCA portion of the auxiliary building is discussed in DCD Tier 2 Section 9A.3.1.2 and Table 9A-4. It contains a summary of the ventilation systems serving fire areas containing Class IE components. This section describes the approach to smoke control for fire areas in the NRCA portion of the auxiliary building that contain the main Class 1E electrical equipment rooms served by the VBS.

Smoke control for the RCA portion of the auxiliary building is discussed in DCD Tier 2 Section 9A.3.1.3. The VAS serves this fire area on a once-through basis. Smoke is removed from this fire area by using portable exhaust fans and flexible ductwork.

Turbine building smoke control features are discussed in DCD Tier 2 Section 9A.3.2. The VTS uses roof mounted exhaust ventilators to pull air through wall louvers. The smoke and heat vents, and if available, the roof mounted exhaust ventilators, vent smoke to outside areas to prevent smoke migration. The dedicated smoke and heat vents provide additional assurance that excessive smoke and heat cannot buildup at the turbine building ceiling, and are designed to conform to NFPA 204, "Standard for Smoke and Heat Venting."

Annex building smoke control features are discussed in DCD Tier 2 Section 9A.3.4. For the elevator shaft and elevator, smoke is removed using the wall exhaust fan or portable exhaust fans and flexible ductwork. Other areas within the annex building are exhausted using the VXS. In the ancillary diesel generator room of the annex building, automatic suppression is provided. After a fire, smoke is removed from this area by using portable exhaust fans and flexible ductwork.

In the diesel generator building, discussed in DCD Tier 2 Section 9A.3.6, smoke and heat ventilation capability is provided. Smoke control features for this area include manually turning on ventilation exhaust fans mounted on the roof over the fire area, or opening the roll-up door and personnel doors and utilizing portable exhaust fans.

The release of smoke and hot gases to the environment is monitored in accordance with the guidance specified in RG 1.101, "Emergency Planning for Nuclear Power Plants." The applicant evaluated the ventilation systems to ensure that inadvertent operation or single failures will not violate the RCAs of the plant.

The power supply and control for the ventilation systems are routed outside of the fire area served by the system. Air intakes for ventilation systems serving areas containing safety-related equipment are located remote from the exhaust air outlets and smoke vents of other fire areas.

There are no safety-related ventilation systems in the AP1000 design; therefore, the guidance related to engineered safety feature filters and gaseous suppression systems are not applicable to the AP1000.

The applicant evaluated the smoke control capability of the normal ventilation system against the criteria specified in NFPA 92A, "Recommended Practice for Smoke-Control Systems," including stair tower pressurization in the auxiliary building. Specifically, the applicant provided dedicated fans to maintain the minimum design pressure difference across the doors in the stair towers S01 and S02, in accordance with the guidance specified in NFPA 92A. Therefore, the staff finds this acceptable.

The staff determined that the applicant demonstrated that the ventilation system is designed such that smoke and other products of combustion following a fire are discharged to an area that will not affect safety-related equipment as specified in BTP CMEB 9.5-1 and is, therefore, acceptable.

9.5.1.5.g Lighting and Communication (Regulatory Position C.5.g of BTP CMEB 9.5-1)

BTP CMEB 9.5-1 recommends that the design should include fixed self contained lighting units with individual 8 hour battery supplies. However, the AP1000 design utilizes alternate emergency lighting in the MCR and remote shutdown workstation that is powered by the Class 1E dc and UPS, that has an expected duration of 72 hours in the event of a loss of normal ac power. A loss of the emergency lighting in either the MCR or the remote shutdown workstation will not result in a loss of the emergency lighting in the other area. The emergency lighting in other plant areas is provided by 8-hour battery-powered, fixed, self-contained units to provide safe ingress and egress of personnel and the operation of equipment following a fire, in the event of a loss of the normal lighting. Portable battery-powered lighting is provided for emergency use by plant personnel. The staff finds this acceptable, because the AP1000 design can still provide lighting to the areas that are vital to safe shutdown in the event of a fire. This is Deviation 9.5.1-6.

Fixed emergency communications are provided at selected locations, independent of the normal plant communications system.

Portable radio communication for use by the plant fire brigade is the responsibility of the COL applicant. This is COL Action Item 9.5.1-1(i).

The applicant demonstrated that the emergency lighting and communications, provided in the event of a fire, provide a level of protection equivalent to that specified in BTP CMEB 9.5-1 and is, therefore, acceptable.

9.5.1.6 Fire Detection and Suppression (Regulatory Position C.6 of BTP CMEB 9.5-1)

The COL applicant is responsible for ensuring that any deviations from the applicable NFPA codes and standards in addition to those specified in the DCD, are incorporated into the final safety analysis report (FSAR) with appropriate technical justification. This is COL Action Item 9.5.1-3.

9.5.1.6.a Fire Detection (Regulatory Position C.6.a of BTP CMEB 9.5-1)

Fire detection systems designed and installed in accordance with the criteria specified in NFPA 72, "Protective Signaling Systems," are provided in all plant areas that contain or present a potential fire exposure to safety-related equipment. The applicant identified no exceptions from the guidance specified in BTP CMEB 9.5-1 and the staff agrees. Therefore, this aspect of the design is acceptable.

9.5.1.6.b Fire Protection Water Supply (Regulatory Position C.6.b of BTP CMEB 9.5-1)

The fire water supply system is designed in accordance with BTP CMEB 9.5-1 and the applicable NFPA standards. An underground yard fire main loop, separate from the sanitary or service water system, and designed and installed in accordance with the criteria specified in NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances," is provided for the AP1000. In addition, indicating isolation valves are provided to permit maintenance or repair of the fire main and outside hydrants (without interrupting the water supply to both the primary and backup fire suppression capability to areas that contain or present an exposure to safety-related equipment). The applicant states that the AP1000 design is a single-unit plant; therefore, cross-connections at multi-unit sites is not part of the AP1000 design.

Two redundant 100-percent capacity fire pumps (one diesel and one electric), which are designed and installed in accordance with the criteria specified in NFPA 20, "Centrifugal Fire Pumps," have been provided. A motor driven jockey pump is used to keep the fire water system full of water and pressurized, as required. Each pump and its driver and controls are separated from the remaining fire pumps by a 3-hour rated fire wall. The fire pumps can be aligned through normally closed valves or through temporary connections to supply water for post-accident services. These include refilling of the PCS water supply tank or supplying the containment spray following a severe accident.

In addition, Section 7.2 of WCAP-15871 states that the fire water supply was calculated on the basis of the largest expected flow rate, but shall not be less than 1135.62 kL (300,000 gallons). This flow rate is based on 1892.71 L/min (500 gpm) for manual hose streams plus the largest design demand of any sprinkler or fixed water supply, as determined by NFPA 13, "Installation

of Sprinkler Systems," or NFPA 15, "Standard for Water Spray Fixed Systems for Fire Protection."

The outside manual hose installation is sufficient to provide an effective hose stream to any onsite location that could present a fire exposure hazard to structures containing safety-related equipment. Fire hydrants are installed approximately every 76.2 m (250 ft) on the yard main. Hose houses are provided in accordance with the criteria specified in NFPA 24. Threads compatible with the local fire department are provided on all hydrants, hose couplings, and standpipe risers.

Fire water is supplied from two separate fresh water storage tanks. The storage capacity of each tank is sufficient to maintain the design fire pump flow rate for at least 2 hours. Either tank can be automatically refilled within 8 hours. Freeze protection is provided as needed using electric immersion heaters. The primary fire water tank is dedicated to the FP system. The secondary fire water tank serves the raw water system but contains water for use by the FP system and the containment spray system. The deviation from Regulatory Position C.6.b of BTP CMEB 9.5-1 provides adequate defense in depth and will not adversely affect the performance of the FP water supply and is, therefore, acceptable. This is Deviation 9.5.1-10.

The fire water tanks are permanently connected to the fire pumps suction piping and are arranged so that the pumps can take suction from either or both tanks. Piping between the fire water sources and the fire pumps is in accordance with NFPA 20. A failure in one tank or its piping cannot cause both tanks to drain.

The standpipe system for areas containing equipment required for safe shutdown following a SSE is designed and supported so that it can withstand the effects of a SSE, and still remain functional. The water supply for the seismic standpipe system are the PCS ancillary water storage tank, and the safety related PCS storage tank as stated in DCD Tier 2 Section 9.5.1.2.1.5. These tanks are not designed with the criteria specified in NFPA 22, "Water Tanks for Private Fire Protection." This system normally operates independently of the rest of the FP system. This volume of water is sufficient to supply two hose streams, each with a flow of 283.9 L/min (75 gpm), for 2 hours. This is Deviation 9.5.1-7. In the event that the PCS is unavailable or additional water is needed, the seismic standpipe system can be supplied from the fire main by manually opening the normally closed cross-connect valve from the plant fire main. On this basis, the staff concludes that the safety-related storage tanks and the manual opening of the cross connect valve are acceptable. These are Deviations 9.5.1-7 and 9.5.1-8.

The PCS water recirculation pumps are not designed and installed in accordance with the criteria specified in NFPA 20. This deviation from the NFPA standards will not adversely affect the performance of the seismically qualified portions of the FP water supply system and is, therefore, acceptable. This is Deviation 9.5.1-9.

9.5.1.6.c Sprinkler and Standpipe Systems (Regulatory Position C.6.c of BTP CMEB 9.5-1)

Automatic sprinkler systems are in accordance with BTP CMEB 9.5-1 and are designed and installed in accordance with the criteria specified in NFPA 13 with the exception of providing individual fire department connections to each sprinkler system. Because the sprinkler systems

are supplied by the plant's FP water supply, individual connections are not necessary. This is Deviation 9.5.1-11. The selection of automatic suppression systems for each plant area are based on the guidance of NFPA 804. Fixed automatic fire suppression is based on the results of the FP analysis. The staff concludes that the automatic sprinkler system design meets the guidance of BTP CMEB 9.5-1, and with the exception of this deviation, this is acceptable.

Standpipes for each building are designed and installed in accordance with the criteria specified in NFPA 14, "Installation of Standpipe and Hose Systems," for Class III service with the exceptions of (1) the water supply to the standpipe inside containment is manually operated, and (2) the containment isolation valves controlling the water supply to standpipes inside containment are not listed by an independent testing laboratories for FP service. The staff concludes that these deviations from the code will not adversely affect the performance of the hose station and standpipe system because these deviations will not prevent manual fire suppression activities inside containment. Therefore, these deviations are acceptable. These are Deviations 9.5.1-12, and -13.

9.5.1.6.d Halon Systems (Regulatory Position C.6.d of BTP CMEB 9.5-1)

Halon fire suppression systems are not used in the design of the AP1000, therefore, the guidance specified in the BTP CMEB 9.5-1 is not applicable.

9.5.1.6.e Carbon Dioxide Systems (Regulatory Position C.6.e of BTP CMEB 9.5-1)

Carbon dioxide fire suppression systems are not used in the design of the AP1000. Therefore, the guidance specified in the BTP CMEB 9.5-1 is not applicable.

9.5.1.6.f Portable Fire Extinguishers (Regulatory Position C.6.f of BTP CMEB 9.5-1)

Portable fire extinguishers are provided in accordance with the criteria specified in NFPA 10, "Portable Fire Extinguishers." They are provided throughout the plant and are readily accessible for use in high radiation areas. However, they are not located within those areas unless the FP analysis indicates that a specific requirement exists. The applicant identified no exceptions from the guidance specified in BTP CMEB 9.5-1 and the staff agrees that the portable fire extinguishers meet BTP CMEB 9.5-1. The staff finds this acceptable.

9.5.1.7 Specific Plant Areas (Regulatory Position C.7 of BTP CMEB 9.5-1)

9.5.1.7.a Primary and Secondary Containment (Regulatory Position C.7.a of BTP CMEB 9.5-1)

Fire protection for the containment is provided as specified in the applicant's fire hazard analysis. A lube oil collection system for the RCPs is not required as the four canned RCPs use water for lubrication, and do not contain oil. Operation of the FP suppression systems located inside containment will not compromise the integrity of the containment or other safety-related systems. Fire detection is provided in the primary containment and annulus for each fire hazard. The type of detection used and the location of the detectors most suitable for the fire hazard identified are identified in DCD Tier 2 Appendix 9A. Manual hose stations are provided in the primary containment as identified in Appendix 9A. Redundant divisions of safety-related cables located in the middle annulus are separated by three-hour fire barriers.

Division B and D cables are located in the upper annulus, and Division A and C cables are located in the lower annulus.

The staff concludes that the applicant provided adequate FP inside primary containment to provide reasonable assurance that one division of safe-shutdown equipment and cables will remain free of fire damage in accordance with NUREG-1242. As stated in Appendix 9A, Section 9A.3.1.1, the safe shutdown components located inside the containment are primarily components of the PXS, the RCS, the steam generator system (SGS), and containment isolation. Hose stations for manual suppression are provided inside containment, however, because of the potential hazard associated with personnel entry into containment during a plant transient, the response of the plant fire brigade may be significantly delayed. Therefore, no credit for manual suppression of fires inside containment during power operations is considered acceptable by the staff. The applicant provided a manual (operated from the MCR) water spray system in zone 1100 AF 11300B over the exposed cable trays located in this fire zone. The applicant identified no exceptions from the guidance specified in BTP CMEB 9.5-1 and the staff agrees that fire protection for the containment meets BTP CMEB 9.5-1. The staff finds this acceptable.

Fire protection inside containment during refueling and maintenance is the responsibility of the COL applicant. This is COL Action Item 9.5.1-1(j).

9.5.1.7.b Control Room Complex (Regulatory Position C.7.b of BTP CMEB 9.5-1)

The MCR complex is noted in Appendix 9A as Fire Zone 1242 AF 12401A. This zone is separated from other plant areas by three-hour rated fire barriers. The ceiling acts as a fire barrier from fires in the room above the MCR. Fire detection is provided in the general area and subfloor areas. Manual hose stations and portable fire extinguishers are provided for fire suppression. Smoke removal is provided by the nonradioactive ventilation system. Breathing apparatus is provided for control room personnel. The above provisions are in accordance with BTP CMEB 9.5-1.

Automatic suppression is not provided in the control room or peripheral rooms in this fire area. Fire detection is not provided in the cabinets or consoles. These are not cosistent with BTP CMEB 9.5-1. These deviations are acceptable as the control room is continuously occupied, the area fire hazard is low, manual suppression capability is available, and the remote shutdown workstation is located in a separate fire area. These are Deviations 9.5.1-14, and -15.

The staff concludes that the deviations from the guidance specified in BTP CMEB 9.5-1 do not adversely affect safety and are, therefore, acceptable, and that with the exception of these deviations, the MCR FP meets BTP CMEB 9.5-1, and is thus acceptable.

9.5.1.7.c Cable Spreading Room (Regulatory Position C.7.c of BTP CMEB 9.5-1)

There are no cable spreading rooms in the AP1000. Therefore, the guidance specified in BTP CMEB 9.5-1 is not applicable.

9.5.1.7.d Plant Computer Rooms (Regulatory Position C.7.d of BTP CMEB 9.5-1)

There are no computers performing safety-related functions in the MCR complex. Non-safety-related computers outside the MCR are separated from safety-related areas by three-hour fire barriers. The applicant identified no exceptions from the guidance specified in BTP CMEB 9.5-1. The staff agrees that the FP design in the plant computer rooms meet BTP CMEB 9.5-1, and finds this acceptable.

9.5.1.7.e Switchgear Rooms (Regulatory Position C.7.e of BTP CMEB 9.5-1)

The electrical equipment and penetration rooms associated with each safety-related division are separated from other plant areas and from redundant divisions by three-hour fire rated barriers. Automatic fire detection, portable fire extinguishers, and manual hose stations are provided. Floor drains are provided for the removal of firefighting water. Smoke removal using the nuclear island nonradioactive ventilation system or portable fans and ductwork is provided for these areas. The applicant identified no exceptions from the guidance specified in BTP CMEB 9.5-1. The staff agrees that the FP design of the switchgear rooms meets BTP CMEB 9.5-1, and finds this acceptable.

9.5.1.7.f Remote Safety-related Panels (Regulatory Position C.7.f of BTP CMEB 9.5-1)

Safety-related panels outside of the control room are separated from other plant areas by three-hour fire barriers. Automatic fire detection, portable fire extinguishers, and manual hose stations are provided. Remote shutdown panels located in the remote shutdown workstation can be electrically isolated from the MCR by a transfer switch. Combustible materials in these areas will be controlled and limited to those required for operation. The control of combustible materials is the responsibility of the COL applicant. This is COL Action Item 9.5.1-1(k).

The applicant identified no deviations from the guidance specified in BTP CMEB 9.5-1. The staff agrees that the FP design of the safety-related panels outside of the control room meets BTP CMEB 9.5-1, and finds this acceptable.

9.5.1.7.g Safety-Related Battery Rooms (Regulatory Position C.7.g of BTP CMEB 9.5-1)

Safety-related battery rooms are separated from each other and other plant areas by three-hour fire rated barriers. Automatic fire detection is provided in the battery rooms. Portable extinguishers and hose stations are readily available outside the battery rooms. Ventilation systems are capable of maintaining the hydrogen concentration in the battery rooms below 2 percent. A loss of the battery room ventilation system alarms in the MCR. The applicant identified no exceptions from the guidance specified in BTP CMEB 9.5-1. The staff agrees that the FP design of the safety-related battery rooms meets BTP CMEB 9.5-1, and finds it acceptable.

9.5.1.7.h Turbine Building (Regulatory Position C.7.h of BTP CMEB 9.5-1)

DCD Tier 2 Section 9A.3.2 states that a fire in the turbine building areas does not affect safe shutdown capability. Fire areas located in the turbine building are separated from adjacent structures containing safety-related equipment by three-hour rated fire barriers. The fire

barriers are designed to maintain structural integrity in the event of a collapse of the turbine building. Openings and penetrations are minimized and are not located in proximity to the turbine lube oil system or generator hydrogen cooling system. The applicant identified no exceptions from the guidance specified in BTP CMEB 9.5-1. The staff agrees that the FP design of the turbine building areas meets BTP CMEB 9.5-1, and finds it acceptable.

9.5.1.7.i Diesel Generators and 9.5.1.7.j Diesel Fuel Storage (Regulatory Positions C.7.i and C.7.j of BTP CMEB 9.5-1)

Portable extinguishers and manual hose stations are readily available outside the fuel storage area. Drainage for firefighting water and a means for manual venting of smoke is provided.

Each diesel generator day tank has a total capacity of 5,678 L (1,500 gallons). Separate 3-hour enclosures and automatic suppression are provided. The tanks are located more then 15 m (50 ft) from buildings containing safety-related equipment. The fuel supply for the ancillary diesel generators is not separated from the diesels by a barrier. The ancillary diesels and the tank are separated from the rest of the plant by an enclosure with a 3-hour fire rating.

In view of the foregoing, the deviations identified by Westinghouse do not adversely affect safety and are, therefore, acceptable.

The standby diesel generators are located in a separate structure, remote from safety-related areas, and separated from each other by three-hour fire barriers. The ancillary diesel generators are located in the same fire area, but are separated from other plant areas containing safety-related equipment by three-hour fire barriers. This deviation from Regulatory Positions C.7.i and C.7.j of BTP CMEB 9.5-1, regarding the lack of three-hour separation between the ancillary diesels does not adversely affect safety because the ancillary diesels are not safety-related and their failure does not adversely affect safe shutdown and is, therefore, acceptable. This is Deviation 9.5.1-16.

Automatic fire suppression is provided in the diesel generator and fuel storage rooms and is designed to actuate during diesel operation, without affecting the diesel. Automatic detection is provided in the diesel generator service modules only. The dry pipe sprinklers provide detection in the diesel generator and fuel storage rooms. This deviation from Regulatory Positions C.7.i and C.7.j of BTP CMEB 9.5-1, does not adversely affect safety because the standby diesel generators are not safety-related and their failure does not adversely affect safe shutdown. Therefore this deviation is acceptable. This is Deviation 9.5.1-17.

9.5.1.7.k Safety-related Pumps (Regulatory Position C.7.k of BTP CMEB 9.5-1)

There are no safety-related pumps required for safe shutdown following a fire in the design of the AP1000. Therefore, the guidance specified in BTP CMEB 9.5-1 is not applicable.

9.5.1.7.l New Fuel Storage Area (Regulatory Position C.7.l of BTP CMEB 9.5-1)

The new fuel storage pit is provided with automatic fire detection, hose stations, and portable extinguishers. Automatic suppression is not provided in the new fuel storage pit. Floor drains are provided to prevent the accumulation of water that could result in an inadvertent criticality.

The new fuel storage pit is located in the same fire area (1200 AF 02) as the rail car bay/filter storage area. The rail car bay/filter storage area is provided with automatic suppression. The applicant identified no exceptions from the guidance specified in BTP CMEB 9.5-1. The staff agrees that the FP design for the new fuel storage area meets BTP CMEB 9.5-1, and finds this acceptable.

9.5.1.7.m Spent Fuel Pool Area (Regulatory Position C.7.m of BTP CMEB 9.5-1)

The fuel-handling area is provided with automatic fire detection, hose stations and portable extinguishers. Automatic suppression is not provided in the new fuel storage pit. The fuel-handling area is located in the same fire area (1200 AF 02) as the rail car bay/filter storage area. The rail car bay/filter storage area is provided with automatic suppression. The applicant identified no exceptions from the guidance specified in BTP CMEB 9.5-1. The staff agrees that the FP design for the spent fuel pool area meets BTP CMEB 9.5-1, and finds this acceptable.

9.5.1.7.n Radwaste and Decontamination (Regulatory Position C.7.n of BTP CMEB 9.5-1)

The radwaste building is separated from other plant areas containing safety-related equipment by three-hour fire rated barriers. A dedicated ventilation system is provided for the radwaste building. Floor drains are sized to handle water flow from fixed automatic FP systems without a significant accumulation of water in the fire area. Curbed areas within the radwaste building have sufficient capacity to retain FP water, to prevent an unmonitored release to the environment.

Automatic fire suppression is provided in the mobile systems facility, waste accumulation room, and packaged waste storage room. Fire detection and hose stations are provided throughout the radwaste building.

The cask washdown pit and the waste disposal container area are located in the same fire area (1200 AF 02) as the rail car bay/filter storage area. The rail car bay/filter storage area is provided with automatic suppression. As described above, Westinghouse identified no exceptions from the guidance specified in BTP CMEB 9.5-1. The staff agrees that the FP design for the radwaste and decontamination areas meet BTP CMEB 9.5-1, and finds this acceptable.

9.5.1.7.o Safety-related Water Tanks (Regulatory Position C.7.o of BTP CMEB 9.5-1)

The CMTs, IRWST, and PCS tank are not susceptible to damage from an exposure fire. The applicant identified no exceptions from the guidance specified in BTP CMEB 9.5-1. The staff agrees that the FP design for the safety related water tanks meet BTP CMEB 9.5-1, and finds this acceptable.

9.5.1.7.p Records Storage Area (Regulatory Position C.7.p of BTP CMEB 9.5-1)

Records storage areas are located and protected such that a fire in these areas will not affect safety-related systems or equipment. The applicant identified no exceptions to the guidance specified in BTP CMEB 9.5-1. The staff agrees that the FP design for the records storage area meets BTP CMEB 9.5-1, and finds this acceptable.

9.5.1.7.q Cooling Towers (Regulatory Position C.7.q of BTP CMEB 9.5-1)

The cooling towers are not used as the ultimate heat sink or for FP purposes, therefore, the guidance specified in BTP CMEB 9.5-1 is not applicable. Fire protection for cooling towers is the responsibility of the COL applicant. This is COL Action Item 9.5.1-1(l).

9.5.1.7.r Miscellaneous Areas (Regulatory Position C.7.r of BTP CMEB 9.5-1)

Miscellaneous areas such as shops, warehouses, auxiliary boiler rooms, fuel oil tanks, and flammable and combustible liquid storage tanks are located and protected such that a fire, or the effects of a fire, will not affect any safety-related equipment. These areas are outside of the containment, which is separated from other plant areas by a 3-hour fire barrier. The applicant identified no deviations from the guidance specified in BTP CMEB 9.5-1. The staff agrees that the FP design for for these areas meet BTP CMEB 9.5-1, and finds this acceptable.

9.5.1.8 Special Protection Guidelines (Regulatory Position C.8 of BTP CMEB 9.5-1)

9.5.1.8.a Storage of Oxygen-Acetylene Fuel Gases (Regulatory Position C.8.a of BTP CMEB 9.5-1)

The proper storage of welding gas cylinders is the responsibility of the COL applicant. This is COL Action Item 9.5.1-1(m).

9.5.1.8.b Storage Areas for Ion Exchange Resins (Regulatory Position C.8.b of BTP CMEB 9.5-1)

The proper storage of ion exchange resins is the responsibility of the COL applicant. This is COL Action Item 9.5.1-1(n).

9.5.1.8.c Hazardous Chemicals (Regulatory Position C.8.c of BTP CMEB 9.5-1)

The proper storage of hazardous chemicals is the responsibility of the COL applicant. This is COL Action Item 9.5.1-1(o).

9.5.1.8.d Materials Containing Radioactivity (Regulatory Position C.8.d of BTP CMEB 9.5-1)

Materials that collect and contain radioactivity such as spent resins, charcoal filters, and HEPA filters are stored in closed metal containers that are located in areas free from ignition sources or combustibles. The applicant identified no deviations from the guidance specified in BTP CMEB 9.5-1. The staff agrees that the FP design associated with the storage of these materials meets BTP CMEB 9.5-1, and finds this acceptable.

9.5.1.9 Evaluation of Fire Protection Open Items and COL Action Items

Open Item 9.5.1-1

Personnel access and egress routes are provided for each fire area. Stairwells outside containment, serving as access or egress routes, are enclosed in gypsum towers, with a

minimum fire resistance rating of two hours. The stairwells are equipped with self-closing doors, with a fire resistance rating of one and a half hours. The NRC staff previously granted Deviation 9.5.1-2 for the use of gypsum stair towers in lieu of concrete or masonry for the AP600 in NUREG 1512, on the basis that there were no missile hazards in the vicinity of the subject stairwells.

Following the events of September 11, 2001, the Federal Emergency Management Agency (FEMA) issued report FEMA 403, "World Trade Center Building Performance Study: Data Collection, Preliminary Observations and Recommendations," dated May 2002. Based on the performance of the gypsum stairwell enclosures in the World Trade Center following the aircraft impacts, Section 8.2.2.1 of the FEMA report recommends the use of impact-resistant enclosures around egress paths, such as stairwells.

In light of this information, the staff has re-considered it's previous acceptance of gypsum stairwell enclosures in lieu of the concrete or masonry enclosure which is specified in BTP CMEB 9.5-1. In RAI 280.001, the staff requested an evaluation of the stairwells that have not been enclosed in masonry or concrete towers with a minimum fire rating of 2 hours as specified in Regulatory Position C.5.a.6. of CMEB 9.5.1. In addition, the staff requested that Westinghouse provide a revision to the DCD to incorporate the original BTP guidance for the use of concrete or masonry enclosures. The staff reviewed the applicant's revised response and determined that the resolution of this issue is inadequate for the following three reasons:

- In place of the gypsum, Westinghouse proposed installation of a fire barrier material noted as a "concrete/steel composite material." This material would be installed throughout the auxiliary, turbine, and annex buildings to enclose stairwells, as shown in the revision to Item 55 in DCD Tier 2 Table 9.5.1-1. The applicant has not demonstrated that the as-built configuration would meet the applicable regulation (GDC 3, "Fire Protection") and the applicable guidance (BTP CMBE 9.5-1). The use of the concrete/steel composite material is inadequate for the following reasons:

    - No documentation or test reports were submitted to verify the rating of the fire barrier. The documentation should demonstrate that this composite material withstood a standard fire exposure as specified in NFPA 251, "Tests of Fire Endurance of Building Construction and Materials," also known as ASTM E119, "Standard Test Method of Fire Tests of Building Construction and Materials." For additional guidance, see Section 3.1.6 of GL 86-10, "Implementation of Fire Protection Requirements."

    - Section 3.2 of GL 86-10 provides additional guidance on Fire Barrier Qualification. It does not appear from the information submitted by the applicant, that the GL 86-10 guidance was evaluated to demonstrate that the composite barrier material provided an equivalent level of safety to concrete or masonry. For example, information pertaining to the following for the fire barrier material were not discussed in the Westinghouse RAI response in regards to:

        - Deviations between the field installation and the tested configuration.

- ASTM E-119 acceptance criteria (hose stream tests results, temperatures on the unexposed side of the barrier, no passage of flames or ignition to unexposed side, etc.)

On this basis, the staff does not agree that Westinghouse has demonstrated that the performance of the composite steel/concrete barrier provides an equivalent level of safety to that provided by meeting BTP CMEB 9.5-1.

- Failure to provide adequate protection for stairwells S03 & S06 in accordance with BTP CMEB 9.5-1.

  The BTP recommends that stairwells outside of primary containment serving as escape routes, access for firefighting or, access routes to areas containing equipment necessary for safe shutdown, be enclosed in concrete or masonry. In the auxiliary building, stairwell S03 provides an entry point to S06 (PCS Valve Room). The PCS system is identified in DCD Tier 2 Section 6.2.2.2.2 as a safety-related system. Stairwells S03 and S06 are located above ground, have no adjacent structures which would provide a shield or additional protection for either stair tower, and have no alternate stairwells for personnel to travel in the event that either S03 or S06 is impacted by an external missile. The applicant revised Item 55 in DCD Tier 2 Table 9.5.1-1 to state that, "There is little need for access to this room (PCS Valve Room). Protection of these stairwells by concrete or masonry walls is not required." The staff disagrees with this statement.

  In the event of an external missile which impacts either stairwell, plant personnel located in plant areas served by these stairwells, would not have an alternate escape route to compensate for the lack of structural protection in stairwells S03 and S06. These stairwells are the primary escape routes and have not been protected in accordance with BTP CMEB 9.5-1.

- For those stairwells where concrete is partially installed on the exterior walls, The applicant stated that the thickness of the concrete varies between 0.61 to 0.91 m (2 to 3 ft) thick. For installation of the composite steel/concrete barrier on the interior walls of these stairwells, the thickness was noted as 20.3 cm (8 in). No analysis was presented to demonstrate from a structural design, that 20.3 cm (8 in) of the composite material would provide an equivalent level of structural integrity to 0.61 to 0.91 m (2 to 3 ft) thickness of concrete. On this basis, the staff does not agree that Westinghouse has demonstrated that the performance of the composite steel/concrete barrier provides an equivalent level of safety to that provided by meeting BTP CMEB 9.5-1.

Therefore, this item is unresolved until further clarification is provided by the applicant. This is Open item 9.5.1-1.

Open Item 9.5.1-2

In RAI 280.011, the NRC staff raised a concern that 41percent of the total fire induced core damage frequency (CDF) is assigned to containment. The containment fire is such a large contributor, and there are areas in containment which exist where redundant safe shutdown

components required following a fire have not been separated by complete fire barriers. Therefore, the NRC staff requested that the applicant perform a mathematical fire model in accordance with NFPA 805, "Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants." The fire model should demonstrate that a fire would be confined to the zone of origin such that redundant components remain free of fire damage. The applicant selected the fire-induced vulnerability evaluation (FIVE) methodology (EPRI TR-100370, "Fire-Induced Vulnerability Evaluation," issued April 1992), which is not a mathematical fire model. FIVE was approved by the NRC in the early 1990's primarily as a tool to provide a qualitative assessment of fire risk for the individual plant examination of external events (IPEEE) to perform fire probabilistic risk assessments (PRAs). The FIVE methodology is limited in that large open areas, such as those in containment, are not capable of being realistically modeled. Therefore, the NRC staff expressed concern that the FIVE methodology was not appropriate to model fires within containment.

The applicant responded to the RAI and stated that NFPA 805 permits the use of the FIVE methodology. The staff responded that Appendix C Section C.2.2., "Fire Model Features and Limitation" of NFPA 805 specifically states that the limitations of each fire model should be taken into consideration, in order to produce reliable results, that will be useful in decision making. This section specifically states that "Some models may not be appropriate for certain conditions and can produce erroneous results if applied incorrectly." The intent of the Appendix C, Table C.2.2.(b), is to enable the user to select the appropriate model for a particular fire area, in order to obtain useful estimates to best approximate the conditions within an enclosure as a result of an internal fire. In addition, NFPA 805 states that the fire model shall be acceptable by the authority having jurisdiction (AHJ). In this case, the AHJ is the NRC. The use of the FIVE methodology has not been accepted outside of the IPEEEs at the NRC. The staff does not agree that the use of FIVE is an appropriate choice to model a fire within containment. Therefore, this item is unresolved. This is Open Item 9.5.1-2.

APPLICABLE NATIONAL FIRE PROTECTION ASSOCIATION CODES, STANDARDS AND RECOMMENDED PRACTICES

NFPA 10, "Portable Fire Extinguishers"
NFPA 13, "Installation of Sprinkler Systems"
NFPA 14, "Installation of Standpipe and Hose Systems"
NFPA 15, "Water Spray Fixed Systems for Fire Protection"
NFPA 20, "Centrifugal Fire Pumps"
NFPA 22, "Water Tanks for Private Fire Protection"
NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances"
NFPA 30, "Flammable and Combustible Liquids Code"
NFPA 50A, "Gaseous Hydrogen Systems at Consumer Sites"
NFPA 72, "Protective Signaling Systems"
NFPA 80, "Fire Doors and Fire Windows"
NFPA 90A, "Installation of Air Conditioning and Ventilation Systems"
NFPA 92A, "Recommended Practice for Smoke-Control Systems"
NFPA 204, "Smoke and Heat Venting"
NFPA 251, "Tests of Fire Endurance of Building Construction and Materials"
NFPA 804, "Fire Protection For Advanced Light Water Reactor Electric Generating Plants"

NFPA 805, "Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants"

SUMMARY OF APPROVED DEVIATIONS AND COL ACTION ITEMS FOR AP1000

I. Approved Deviations

9.5.1 - 1 - Single failure of primary and backup fire suppression inside containment.
9.5.1 - 2 - Cable insulation in concealed spaces of the control room, technical support center, remote shutdown workstation.
9.5.1 - 3 - Definition of safe shutdown for AP600 and AP1000.
9.5.1 - 4 - Achievement of cold shutdown in 72 hours.
9.5.1 - 5 - Breathing air storage tanks located in the auxiliary building.
9.5.1 - 6 - Self contained emergency lighting in the control room and remote shutdown workstation.
9.5.1 - 7 - PCS tanks compliance with NFPA 22.
9.5.1 - 8 - Manual connection between seismic standpipe and yard loop.
9.5.1 - 9 - PCS recirculation pumps compliance with NFPA 20.
9.5.1 - 10 - Dual use of secondary fire water tank.
9.5.1 - 11 - Fire department connections to the sprinkler systems.
9.5.1 - 12 - Manual operation of standpipe inside containment.
9.5.1 - 13 - Containment isolation valves not listed for fire protection service.
9.5.1 - 14 - Automatic suppression of peripheral rooms in control room complex.
9.5.1 - 15 - Fire detection in MCR cabinets and consoles.
9.5.1 - 16 - Fire separation of ancillary diesels.
9.5.1 - 17 - Fire detection in diesel generator rooms. Automatic detection not provided in the D/G and fuel storage rooms.

II. COL Action Items

9.5.1 - 1(a) - Fire protection program.
9.5.1 - 1(b) - Implementation of fire protection program.
9.5.1 - 1(c) - Administrative controls.
9.5.1 - 1(d) - Fire brigade.
9.5.1 - 1(e) - Quality assurance program.
9.5.1 - 1(f) - Inspection and maintenance of fire doors, keys for the fire brigade, and marking of exit routes.
9.5.1 - 1(g) - Sampling of water drainage for contamination following a fire.
9.5.1 - 1(h) - Control of combustibles.
9.5.1 - 1(i) - Portable radio communications for the fire brigade.
9.5.1 - 1(j) - Fire protection inside containment during refueling and maintenance.
9.5.1 - 1(k) - Control of combustibles in areas containing safety-related equipment.
9.5.1 - 1(l) - Cooling tower fire protection.
9.5.1 - 1(m) - Storage of welding gas cylinders.
9.5.1 - 1(n) - Storage of ion exchange resins.
9.5.1 - 1(o) - Storage of hazardous chemicals.
9.5.1 - 2 - Fire hazard analysis.
9.5.1 - 3 - Deviations from NFPA codes and standards.

9.5.2 Communication System

The staff used SRP Section 9.5.2 acceptance criteria and the guidance in EPRI ALWR utility requirements document (URD) for the review of AP1000 communication systems. The criteria relies, in part, on previous plant communication systems operating history. Communication systems are deemed acceptable if the integrated system can provide effective plant personnel communications for a variety of scenarios during normal, incident and accident conditions and environments. Such environmental considerations include weather, moisture, noise level and electro magnetic interference/radio frequency interference (EMI/RFI) conditions such that effective communication can be accomplished in all vital areas. Environmental conditions also include fires and radiological events in which personnel must be able to effectively communicate through respiratory protection.

10 CFR 73.55(e), "Detection Aids," 10 CFR 73.55(f), "Communication Requirements," and 10 CFR 73.55(g), "Testing and Maintenance," contain certain design requirements for certain communication systems. These requirements are summarized as follows:

- secondary power supplies for non-portable communications equipment must be located in vital areas,
- certain on-duty security personnel shall be capable of continuous communication with individuals in manned alarm stations,
- use of conventional telephone service,
- use of continuous two-way communication in addition to conventional phone via radio or microwave,
- non-portable equipment shall remain operable in the event of normal power loss,
- communications equipment shall be maintained in operable condition, and
- certain equipment shall be tested on a shift basis or daily as required by section g.

Section 4.6.1, chapter 10 of the URD covers plant operations and maintenance communications as well as external communications with outside organizations. The communication system designer should include the system requirements and an analysis to ensure the requirements meet the needs of the system. The URD also discusses that the primary and dedicated communication between operations operations and maintenance personnel and maintenance should be portable and wireless with the appropriate support equipment. A plant-wide paging system and in-plant telephone system should be included. Dedicated phone links should be included to effect offsite communications.

DCD Tier 2 Section 9.5.2, "Communication System," contains the description of the communication system. The system consists of the following subsystems:

- Wireless telephone system
- Telephone/page system
- Private automatic branch exchange (PABX) system
- Sound-powered system
- Emergency response facility communications
- Security communication system

According to the DCD, the PABX and wireless communications fulfill the requirements of 10CFR 73.55 (e) and (f). Communication to be used with respiratory equipment shall be designed and selected according to the guidelines of EPRI Report NP 6559, "Voice Communication Systems Compatible with Respiratory Protection."

The following is a summary of the communication systems described in the DCD.

Wireless Telephone System

The system consists of portable handsets and headsets, an antenna system and wireless phone switch. This is the primary means of plant operations and maintenance personnel communications. The page, PABX phone and sound-powered systems are backups to the wireless phone system. The system power backup is an uninterruptible power supply (UPS) that will supply power for 2 hours on a loss of normal power.

Telephone/Page System

The system consists of handsets, amplifiers, loudspeakers, tone generators, test and distribution cabinet, and other support equipment. The system has one paging and five party lines. This allows zone paging, zone to zone paging, and all zone paging. This system is also used for certain alarms designated by the COL applicant. These alarm selections are controlled and programmed from the MCR. Alarms notification will automatically merge the zones for an alarm actuation. The system power backup is a UPS that will supply power for 2 hours on a loss of normal power.

Private Automatic Branch Exchange (PABX) System

The PABX system provides communications between system stations and has call transfer capability and conference calling. The MCR and TSC have additional capabilities to program selected numbers for particular stations. The PABX interfaces with the wireless phone system, local telephone systems, page system, and direct extensions outside the plant. The system power backup is a UPS that will supply power for 2 hours on a loss of normal power.

Sound-Powered System

This system is used for refueling and for startup and maintenance testing. It does not require an external power supply for operation.

The DCD states that the above mentioned systems will be tested according to their use. That is, those systems not frequently used will be tested "at periodic intervals to demonstrate operability when required." For those systems that are in routine use, that use will demonstrate that the system is operating correctly. The remaining systems, emergency response facility and security communication systems are under the heading "Combined License Information," in DCD Tier 2 Section 9.5.2.5, and discussed below.

Emergency Response Facility Communications

DCD Tier 2 Section 9.5.2.5.2, "Emergency Response Facility Communications," states that the emergency response facility communication systems, including the crisis management radio system will be addressed by the COL applicant. This is COL Action Item 9.5.2-1.

Security Communication System

DCD Tier 2 Section 9.5.2.5.3, "Security Communications," states that specific details for the security communication system are the responsibility of the COL applicant, as described in DCD Tier 2 Sections 13.6.9 and 13.6.10. DCD Tier 2 Sections 13.6.9 and 13.6.10 states that on a loss of normal power, the security communication system receives power from the security-dedicated uninterruptible power supply (UPS). The UPS is capable of sustaining operation for a minimum of 24 hours. Specific details of the security communication system, including testing, will be addressed by the COL applicant. This is COL Action Item 9.5.2-2.

On the basis of its review of the limited design detail provided in the DCD, the staff concludes that the AP1000 communication system may provide effective communication, given the following open items are resolved:

- 10CFR 73.55 (e) (f) discusses that placement of backup power supplies for certain communication systems be in vital areas. This is mentioned in DCD Tier 2 Section 13.6, "Security," for “vital equipment,” but it is not clear that the “non-portable communication equipment” specified in 10CFR 73.55 (f) is vital equipment. The DCD should clarify the categorization of communication equipment and the requirement addressing this equipment in 10CFR 73.55 (f). This is Open item 9.5.2-1.

- 10CFR 73.55 (g) mentions testing requirements for certain communication systems. This has not been mentioned in DCD Tier 2 Section 9.5.2. This is Open Item 9.5.2-2.

- The COL applicant should address the issue of Bulletin BL-80-15 for recommendations of loss of the emergency notification system due to a loss of offsite power. This is COL Action Item 9.5.2-3. Inclusion of this COL information in the DCD is Open Item 9.5.2-3.

- SRP Section 9.5.2 provides reviewer guidance on the design of communication systems (i.e intra-pant and plant to offsite). Part of that guidance states, “Communications system will be protected from EMI/RFI effects of other plant equipment and there will be adequate testing and field measurements where necessary to demonstrate effective communications.” In addition, SRP Section 9.5.2 discusses the general requirement that addresses the need for communication equipment to provide effective communication during the “full spectrum of ...conditions ...under maximum potential noise levels.”

  The staff believes the DCD has not sufficiently covered communication testing for plant startup and operations in sufficient detail to facilitate understanding of how effective communications will be demonstrated including EMI/RFI effects on the equipment. The staff also believe the DCD has not sufficiently addressed how effective communications will be sustained for maximum potential noise levels. This is Open Item 9.5.2-4.

9.5.3 Plant Lighting System

Regulatory Evaluation

Acceptance criteria in SRP Section 9.5.3 states that the acceptability of the design of the normal, emergency, panel, and security lighting is based on the degree of similarity of systems design with those for previously approved plants with satisfactory operating experience. There are no GDC or regulatory guides that directly apply to the safety-related performance requirements for the lighting system. The lighting system for the AP1000 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 (IES) Lighting Handbook.

Technical Evaluation

The plant lighting system includes normal, emergency, panel, and security lighting. The normal and emergency lighting in the MCR and remote shutdown area are non-Class 1E. The normal lighting provides normal illumination during plant operating, maintenance, and test conditions. The emergency lighting provides illumination in areas where emergency operations are performed upon loss of normal lighting. The security lighting system is site-specific and will be addressed by the COL applicant. The security lighting system will be described and evaluated in the in Section 13.6 of this report upon resolution of Open Item 13.6-1.

9.5.3.1 Normal Lighting System

Power to the normal lighting system is supplied from the non-Class 1E power distribution system, and is backed-up by the onsite standby diesel generators. The lighting load is distributed between the two diesel generator buses. The motor control centers, powering the normal lighting system, are energized from the 480 Vac load centers. Lighting distribution panel branch circuit breakers are controlled by a lighting control system. Approximately 75 percent of the normal lighting is tripped off automatically upon loss of normal ac power (except in the MCR and in the remote shutdown area) to limit the load on the onsite diesel generators. The lighting control system allows an operator to energize or de-energize lighting in selected areas, based on the actual need and available power from the onsite standby diesel generator. The circuits to the individual ac lighting fixtures are staggered as much as practical. The staggered circuits are fed from separate buses to ensure that some lighting is retained in the event of a bus or circuit failure. The lighting fixtures located in the vicinity of safety-related equipment are supported so that they do not adversely impact this equipment when subjected to the seismic loading of a SSE.

Power to the normal lighting system is supplied from the non-Class 1E ac power distribution system at the following voltage levels:

- 480/277 V, 3-phase, 4-wire, grounded neutral system lighting panels are fed from the 480 V motor control centers. This source is for the lighting fixtures rated at 480/277 V and for the welding receptacles.

- 208/120 V, 3-phase, 4-wire, grounded neutral system distribution panels are fed from the 480 V motor control centers, through dry-type 480-208/120 V transformers. This source is for the convenience lighting and utility receptacles.

- 208/120 V, 3-phase, 4-wire, grounded neutral regulated power fed from 480 V motor control centers, through the Class 1E 480-208/120 V voltage regulating transformers (division B and C). This source is for the normal and emergency lighting in the MCR and remote shutdown area, and is isolated through two series of fuses.

The staff considers that the information provided is sufficient to meet SRP Section 9.5.3 and, therefore, acceptable.

9.5.3.2 Emergency Lighting

Power to the emergency lighting in the MCR and the remote shutdown area is supplied from the Class 1E 125 Vdc switchboard through the Class 1E 208Y/120 Vac inverters and is isolated through two series fuses. Three hour barrier separation is provided between redundant emergency power supplies and cables outside the MCR and remote shutdown area. The control room lighting complies with human factors requirements by using semi-indirect, low-glare lighting fixtures and programmable dimming features. The control room emergency lighting is integrated with the normal lighting, which consists of identical lighting fixtures and dimming features. The emergency lighting system is designed so that, to the extent possible, alternate emergency lighting fixtures are fed from separate divisions of the Class 1E dc and UPS system. Both normal and emergency lighting fixtures, controllers, dimmers, and the associated cables used in the MCR and remote shutdown area are non-Class 1E. The ceiling grid network, raceways, and fixtures utilize seismic supports

Following the 72-hour period after a loss of all ac power sources, the lighting circuits in the MCR is powered from two ancillary ac generators.

In areas outside the MCR and the remote shutdown area, emergency lighting is provided by 8-hour, self-contained, battery-pack, sealed-beam lighting units. These units are powered from the non-Class 1E and provide illumination for safe ingress and egress of personnel following a loss of normal lighting for areas that are involved in power recovery. In addition, these units are provided in areas where normal actions are required for operation of equipment needed during a fire. These units are normally powered from the non-Class 1E 480/277 Vac motor control centers.

The staff considers that the information provided is sufficient to meet SRP Section 9.5.3 and, therefore, acceptable

9.5.3.3 Panel Lighting

Panel lighting is designed to provide lighting in the MCR at the safety panels. It consists of lighting fixtures located on or nearby safety panels in the MCR. The panel lights are continuously energized. The fixtures are powered from the Division B and C Class 1E inverters through Class 1E distribution panels. The circuits are treated as Class 1E. The panel lighting

circuits up to the lighting fixtures are classified as associated and routed in Seismic Category I raceways. The bulbs are not seismically qualified.

The staff has evaluated and determined that the panel lighting design is acceptable because the panel lighting circuits to the lighting fixtures are powered from the Division B and C Class 1E inverters, through Class 1E distribution panels, and are routed in seismic Category I raceways.

9.5.3.4 Conclusion

Based on its review, the staff concludes that the lighting system for the AP1000 is 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 (IES) Lighting Handbooks and is, therefore, acceptable.

9.5.4 Standby Diesel Generator Auxiliary Support Systems

There are two redundant onsite standby DG units in the AP1000 design to provide power, assuming a single active component failure, to selected non-safety-related ac loads in the event of a loss of normal and preferred ac power supplies. Each standby DG unit is an independent system complete with its necessary support systems that include:

- standby DG cooling system
- standby DG starting system
- standby DG lubricating oil system
- standby DG combustion air intake and exhaust system

The standby DGs and their support systems have no safety-related functions, and therefore, have no nuclear safety design basis. They are classified as AP1000 Class D, non-seismic (NS) systems which incorporate standard industrial quality assurance standards to provide appropriate integrity and function. The standby DGs and their support systems are also included in the AP1000 IPSAC and DRAP programs.

In addition to the two standby DG units, there are two redundant ancillary ac DGs located in the annex building to provide long term backup ac power supplies for post-accident monitoring, MCR lighting, MCR and I&C room ventilation, and PCS and spent fuel pool water makeup, when all other sources of power are not available. The ancillary DGs are not needed for the first 72 hours following a loss of all other ac sources. The ancillary DGs classified as AP1000 Class D systems are commercial-grade, skid-mounted, self-contained units packaged with all necessary support systems and controls. The ancillary DGs are also included in the AP1000 IPSAC and DRAP programs. The staff’s evaluation of the ancillary DGs is addressed in Section 8.3 of this report.

9.5.5 Standby DG Cooling System

The staff followed the guidance of SRP Section 9.5.5, "Emergency Diesel Engine Cooling Water System," to review the standby DG cooling system in AP1000 design. The acceptance

criteria in SRP Section 9.5.5 are based on meeting applicable requirements of GDC 2, 4, 5, 17, 44, 45, and 46.

The standby DG cooling system, in the AP1000 design, serves no safety-related function, and therefore, has no nuclear safety design basis. The system is an independent closed loop cooling system, rejecting engine heat through two separate roof-mounted, fan-cooled radiators. The system consists of two separate cooling loops, each maintained at a temperature required for optimum engine performance by separate engine-driven coolant water circulating pumps. One loop cools the engine cylinder block, jacket, and head area, while the other loop cools the oil cooler and turbocharger aftercooler. The cooling loop, which cools the engine cylinder blocks, jacket, and head areas, includes a keep-warm circuit consisting of a temperature controlled electric heater and an ac motor-driven water circulating pump.

Based on its review, the staff determined that the standby DG cooling system is a non-safety-related system and serves no safety-related function, and its failure does not lead to the failure of any safety systems. The staff, therefore concludes that the requirements of GDC 2, 4, 5, 17, 44, 45 and 46, and the guidance of SRP Section 9.5.5 do not apply. Also, as described in the above Section 9.5.4 of this report, the standby DG unit, which includes the standby DG cooling system, is classified as AP1000 Class D system, and is included in the AP1000 IPSAC and DRAP programs. Based on the above, and the fact that its failure does not prevent safe shutdown, the staff finds the standby DG cooling system acceptable.

9.5.6 Standby Diesel Engine Starting System

The staff followed the guidance of SRP Section 9.5.6, "Emergency Diesel Engine Starting System," to review the standby diesel engine starting system in AP1000 design. The acceptance criteria in SRP Section 9.5.6 are based on meeting applicable requirements of GDC 2, 4, 5, and 17.

The standby DG starting system, in the AP1000 design, serves no safety-related function, and therefore, has no nuclear safety design basis. The system consists of an ac motor-driven, air-cooled compressor, a compressor inlet air filter, an air-cooled aftercooler, an in-line air filter, a refrigerant dryer, and an air receiver with sufficient storage capacity for three diesel engine starts. In DCD Tier 2 Section 8.3.1.1.2.1, Westinghouse stated that the DG starting system will be consistent with manufacturer's recommendations regarding the devices to crank the engine, duration of the cranking cycle, the number of engine revolutions per start attempt, volume and design pressure of the air receivers, and compressor size.

Based on its review, the staff determined that the standby DG starting system is a non-safety-related system and serves no safety-related function, and its failure does not lead to the failure of any safety systems. The staff, therefore, concludes that the requirements of GDC 2, 4, 5, and 17, and the guidance of SRP Section 9.5.6 do not apply. Also, as described in the above Section 9.5.4 of this report, the standby DG unit which includes the standby DG starting system is classified as AP1000 Class D system, and is included in the AP1000 IPSAC and DRAP programs. Based on the above, and the fact that its failure will not prevent safe shutdown, the staff finds the standby DG starting system acceptable.

9.5.7 Standby Diesel Generator Lubricating Oil System

The staff followed the guidance of SRP Section 9.5.7, "Emergency Diesel Engine Lubrication System," to review the standby DG lubricating oil system in AP1000 design. The acceptance criteria in SRP Section 9.5.7 are based on meeting applicable requirements of GDC 2, 4, 5, and 17.

The standby DG lubricating oil system, in the AP1000 design, serves no safety-related function, and therefore, has no nuclear safety design basis. The system is contained on the engine skid and includes an engine oil sump, a main engine driven oil pump, and a continuous engine prelube system consisting of an ac and dc motor driven prelube pump and electric heater. The prelube system maintains the engine lubrication system in service when the DG is in standby mode. The lube oil is circulated through the engine and various filters and coolers to maintain the lube oil properties suitable for engine lubrication.

Based on its review, the staff determined that the standby DG lubricating oil system is a non-safety-related system and serves no safety-related function, and its failure does not lead to the failure of any safety systems. The staff, therefore, concludes that the requirements of GDC 2, 4, 5 and 17, and the guidance of SRP Section 9.5.7 do not apply. Also, as described in the above Section 9.5.4 of this report, the standby DG unit, which includes the standby DG lubricating oil system, is classified as AP1000 Class D system; and included in the AP1000 IPSAC and DRAP programs. Based on the above, and the fact that its failure will not prevent safe shutdown, the staff finds the standby DG lubricating oil system acceptable.

9.5.8 Standby Diesel Generator Combustion Air Intake and Exhaust System

The staff followed the guidance of SRP Section 9.5.8, "Emergency Diesel Engine Combustion Air intake and Exhaust System," to review the standby DG combustion air intake and exhaust system in AP1000 design. The acceptance criteria in SRP Section 9.5.8 are based on meeting applicable requirements of GDC 2, 4, 5, and 17.

The standby DG combustion air intake and exhaust system, in the AP1000 design, serves no safety-related function, and therefore, has no nuclear safety design basis. The system provides combustion air directly from the outside to the diesel engine while protecting it from dust, rain, snow and other environmental particulates. It then discharges exhaust gases from the engine to the outside of the DG building more than 20 feet higher than the air intake. The combustion air circuit includes weather protected dry type inlet air filters piped directly to the inlet connections of the diesel engine-mounted turbochargers. The engine exhaust gas circuit consists of the engine exhaust gas discharge pipes from the turbocharger outlets to a single vertically mounted outdoor silencer which discharges to the atmosphere. The applicant stated that manufacturer’s recommendations are considered in the design of features to protect the silencer module and other system components from possible clogging due to adverse atmospheric conditions, such as dust storms, rain, ice, and snow.

Based on its review, the staff determined that the standby DG combustion air intake and exhaust system is a non-safety-related system and serves no safety-related function, and its failure does not lead to the failure of any safety systems. The staff, therefore, concludes that the requirements of GDC 2, 4, 5 and 17, and the guidance of SRP Section 9.5.8 do not apply.

Also, as described in the above Section 9.5.4 of this report, the standby DG unit, which includes the standby DG combustion air intake and exhaust system, is classified as AP1000 Class D system, and is included in the AP1000 IPSAC and DRAP programs. Based on the above, and the fact that its failure will not prevent safe shutdown, the staff finds the standby DG combustion air intake and exhaust system acceptable.

9.5.9 DG and Auxiliary Boiler Fuel Oil System

The staff followed the guidance of SRP Section 9.5.4, "Standby Diesel Generator Fuel Oil Storage and Transfer System," to review the system. The acceptance criteria in SRP Section 9.5.4 are based on meeting applicable requirements of GDC 2, 4, 5, and 17.

The DG and auxiliary boiler fuel oil system, in the AP1000 design, serves no safety-related function, and therefore, has no nuclear safety design basis. The function of the DG and auxiliary boiler fuel oil system is to store and provide fuel oil for the onsite non-safety-related standby DGs, the auxiliary boiler, and the ancillary DGs. The system is designed to: provide a supply of fuel oil sufficient to operate each standby DG at continuous rating for 7 days; provide a 7-day fuel supply for auxiliary boiler operation, with half of the required fuel stored in each tank; and provide a 4-day fuel supply for the two ancillary DGs. The system is classified as AP1000 Class D system and is included in the AP1000 IPSAC and DRAP programs.

The DG and auxiliary boiler fuel oil system consists of two independent, full capacity standby DG fuel oil storage and transfer system, one for each standby DG, the auxiliary boiler fuel oil supply system, and the ancillary DG fuel oil supply system.

The fuel oil storage tanks for the standby DGs and auxiliary boiler are replenished from trucks (or other mobile suppliers) as required to maintain an adequate supply for the auxiliary boilers, and a seven day supply for each standby DG. Each storage tank is equipped with a vent line to atmosphere at the top of the tank that ends with a flame arrester. A tank fill line runs to each tank and is extended to the truck unloading station. The fill line incorporates a normally closed valve and a filler cap at the end to preclude the entrance of water. The fill line is above grade. The fill line has a strainer located downstream of the isolation valve to prevent entrance of deleterious solid material into the tank. A water removal port is located at the tank sump.

Each fuel oil transfer pump takes suction from a fuel oil storage tank and discharges fuel oil to the DG fuel oil day tank. Each pump is capable of supplying its DG and, simultaneously, increasing the inventory in the fuel oil day tank. The fuel oil transfer pump is automatically started and stopped on day tank level control. Part of the pump discharge flow is returned to the storage tank via the recirculation line. The filter in the discharge line to the day tank is monitored by measuring differential pressures across the filter and by providing a high differential pressure alarm. The fuel oil storage tank for each standby DG also provides fuel oil for the auxiliary boiler. Fuel oil for the standby DG is reserved by tapping auxiliary boiler fuel oil from elevated nozzles above the required DG fuel oil storage level.

Fuel oil to the auxiliary boiler is supplied by two suction supply lines, (one from each tank), to two separate fuel oil supply pumping stations. One auxiliary boiler fuel oil pumping station is located in each DG fuel transfer pump enclosure. Both pumps discharge to the auxiliary boiler through a common discharge line. The pumps are full capacity with one for service and the

other as standby. The pump motor and pump are mounted on a common base plate. The system includes a recirculation fuel oil return line from the boiler back to the storage tanks.

The fuel oil storage tank for the ancillary DGs, which consists of a single 100 percent capacity tank serving both ancillary DGs, is replenished from trucks (or other mobile supplier) as required to maintain a 4-day supply for both DGs. The ancillary DG fuel oil storage tank is Seismic Category II and is located in the same room as the generators.

Based on its review, the staff determined that the DG and auxiliary boiler fuel oil system is a non-safety-related system and serves no safety-related function, and its failure does not lead to the failure of any safety systems. The staff, therefore, concludes that the requirements of GDC 2, 4, 5 and 17, and the guidance of SRP Section 9.5.4 do not apply. Also, as described in the above, the DG and auxiliary boiler fuel oil system is classified as AP1000 Class D system, and is included in the AP1000 IPSAC and DRAP programs. Based on the above, and the fact that its failure will not prevent safe shutdown, the staff finds the DG and auxiliary boiler fuel oil system acceptable.