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CHAPTER 9.0

AUXILIARY SYSTEMS

This chapter provides information concerning the auxiliary systems included in the SNUPPS standard plant. Those systems that are essential for the safe shutdown of the plant or the protection of the health and safety of the public are identified. The description of each system, the design bases for the system and for critical components, a safety evaluation demonstrating how the system satisfies the design bases, the testing and inspection to be performed to verify system capability and reliability, and the required instrumentation and controls are provided. Those aspects of the auxiliary systems that have little or no relationship to protection of the public against exposure to radiation are described in enough detail to allow understanding of the auxiliary system design and function. Emphasis is placed on those aspects of design and operation that might affect the reactor and its safety features or contribute to the control of radioactivity.

The capability of the system to function without compromising the safe operation of the plant under both normal operating or transient situations is clearly shown by the information provided, i.e., a failure analysis.

9.1 FUEL STORAGE AND HANDLING

The power block has its own fuel storage and handling facility. The onsite fuel storage and handling facilities are designed to accommodate both new and spent fuel assemblies.

9.1.1 NEW FUEL STORAGE

A new fuel storage facility (NFSF) is located within the fuel building, and provides onsite dry storage for 66 new fuel elements (approximately one-third core).

9.1.1.1 Design Bases

The NFSF maintains the new fuel elements in a subcritical array during all postulated design basis events.

9.1.1.1.1 Safety Design Bases

SAFETY DESIGN BASIS ONE - The NFSF is protected from the effects of natural phenomena, including earthquakes, tornadoes, hurricanes, floods, and external missiles (GDC-2).

SAFETY DESIGN BASIS TWO - The NFSF will perform its intended function and maintain structural integrity after an SSE or following a postulated hazard, such as fire, internal missiles, or pipe break (GDC-3 and 4).

SAFETY DESIGN BASIS THREE - Components of the NFSF are not shared with other units (GDC-5).

SAFETY DESIGN BASIS FOUR - The NFSF is designed to store reactor core fuel assemblies in a subcritical array (GDC-62).

SAFETY DESIGN BASIS FIVE - The NFSF meets the requirements of 10 CFR 73.40, 10 CFR 73.55, and 10 CFR 73.60, which require physical protection of special nuclear material while in storage.

SAFETY DESIGN BASIS SIX - The NFSF, including the new fuel storage racks, precludes insertion of new fuel assemblies in other than prescribed locations within the NFSF.

SAFETY DESIGN BASIS SEVEN - The new fuel storage racks are designed for the following loads and combinations thereof:

a. Dead loads

b. Live loads (fuel assemblies)

c. Crane uplift load (maximum of 5,000 pounds)

d. Safe shutdown earthquake loads

e. Operating basis earthquake loads

SAFETY DESIGN BASIS EIGHT - The NFSF is monitored for evidence of criticality, in compliance with GDC-63 and 10 CFR 70.24.

SAFETY DESIGN BASIS NINE - The capability to inspect the NFSF is provided (GDC-61).

9.1.1.1.2 Power Generation Design Basis

There are no power generation design bases associated with the NFSF.

9.1.1.2 Facility Description

The NFSF is a separate and protected area containing fuel storage racks, and is enclosed by a reinforced concrete structure with an associated steel plate top containing hinged openings covering every two fuel assemblies. The concrete vault is described in Section 3.8. Drainage is provided to prevent accumulation of water within the vault. The new fuel storage racks are carbon steel with stainless steel guides where the rack comes into contact with the fuel assembly. New fuel assemblies are received, inspected, and stored in the new fuel storage racks in the NFSF. A total of 66 new fuel assemblies can

be stored in the racks in a lattice array having a minimum center-to-center distance of 21 inches in both horizontal directions. The NFSF is shown in Figures 1.2-20 and 1.2-21. Figure 9.1-1 shows a typical new fuel storage rack module. Figures 9.1-1a and 9.1-1b show the fresh fuel storage array layout and the fresh fuel storage cell nominal dimensions.

The new fuel storage rack modules are designed and fabricated as four vertical continuous cells for the storage of fuel assemblies. The cells are continuous stainless steel tubes to ensure good vertical alignment and stability for the fuel assemblies in storage position. Design, fabrication, and installation of the new fuel storage racks are based on the ASME Code specifications. Stresses in a fully loaded rack are below the design stress level defined in the ASME Code, Section III, Appendix XVII. The new fuel storage racks are designed to seismic Category I criteria, and are anchored to the seismic Category I floor and walls of the NFSF.

The criticality analysis shows that the spacing between fuel assemblies in the storage racks is sufficient to maintain the array in a subcritical condition, even when fully loaded. New fuel is stored in 21-inch, center-to-center racks in the NFSF, with no water present, but which are designed to prevent accidental criticality even if unborated water is present. For the flooded condition, assuming new fuel of the highest anticipated enrichment (5.0 weight percent U-235) in place, the effective multiplication factor does not exceed 0.95. The effective multiplication factor does not exceed 0.98 with fuel of the highest anticipated enrichment in place, assuming possible sources of moderation, such as aqueous foam or mist.

In the analysis for the storage facilities, the fuel assemblies are assumed to be in their most reactive condition, namely fresh or undepleted, and with no control rods or removable neutron absorbers present. Credit is taken for the inherent neutron-absorbing effect of materials of construction for the racks. Assemblies cannot be closer together than the design separation provided by the storage facility, except in special cases such as in fuel shipping containers where analyses are carried out to establish the acceptability of the design. The mechanical integrity of the fuel assembly is assumed.

Section 9.1.4 provides an evaluation to demonstrate that the new fuel storage racks can withstand a maximum crane uplift force of 5,000 pounds. A dropped fuel assembly cannot impact the racks, since a steel cover is provided over the new fuel storage area.

To further ensure that no fuel can be damaged, each storage cell is designed to prevent any portion of a fuel assembly or core component (e.g., control rods) from extending above support or guiding surfaces of the storage cell. See Table 9.1-1 for the design data for the NFSF.

9.1.1.3 Safety Evaluation

The safety evaluations given below correspond to the safety design bases in Section 9.1.1.1.1.

SAFETY EVALUATION ONE - The NFSF is located in the fuel building. The fuel building is designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other appropriate natural phenomena. Sections 3.3, 3.4, 3.5, 3.7(B), and 3.8 provide the bases for the adequacy of the structural design of the building.

SAFETY EVALUATION TWO - The NFSF is designed to remain functional after an SSE. Sections 3.7(B).2 and 3.9(B) provide the design loading conditions that were considered. Sections 3.5, 3.6, and 9.5.1 provide the hazards analyses to assure that the facility is properly protected.

SAFETY EVALUATION THREE - Each standard power block has an NFSF capable of storing one-third of a core. No sharing is necessary.

SAFETY EVALUATION FOUR - The criticality analysis demonstrates that a 21-inch (square pitch) center-to-center storage spacing of fuel assemblies in both horizontal directions ensures the subcriticality of new fuel assemblies within the NFSF.

SAFETY EVALUATION FIVE - The new fuel is stored in a totally enclosed vault with reinforced concrete walls and a steel plate top. The new fuel storage vault is located within the fuel building. The security measures taken for the protection of the new fuel against industrial sabotage and theft are discussed in Section 13.6 of the Site Addenda.

SAFETY EVALUATION SIX - A steel checker plate cover is provided over the entire new fuel storage concrete vault. Hinged covers are provided directly over each fuel storage position. The covers and fuel racks are sized to prevent insertion of a fuel assembly in other than its prescribed location.

SAFETY EVALUATION SEVEN - The new fuel storage racks, loaded with fuel, are designed to minimize the distortion or buckling of rack arrangements. Stresses in the fully loaded racks do not exceed stresses specified by the ASME Code, Section III, Appendix XVII. This condition ensures a $k_{eff} \leq 0.98$. The new fuel storage equipment is designed to meet seismic Category I requirements. The crane hookup to the new fuel assemblies is done manually and under administrative control. The new fuel storage racks are designed to withstand a maximum uplift force of 5,000 pounds. The impact load of a dropped fuel assembly is taken by the checker plate covering the new fuel assemblies. The checker plate has been analyzed and determined capable of sustaining the maximum fuel assembly drop.

The probability of a dropped mass accident occurring is remote since:

a. New fuel storage racks in the new fuel storage vault are protected from dropped objects by a steel protective cover.

b. Safe handling features, as described in Section 9.1.4, are incorporated into the new fuel assembly handling tools.

SAFETY EVALUATION EIGHT - As described in Section 9.1.1.5, a monitoring system is provided to initiate an audible alarm if high radiation from an accidental criticality occurs.

SAFETY EVALUATION NINE - As described in Section 9.1.1.4, the NFSF is accessible for periodic inspection.

9.1.1.4 Tests and Inspections

The NFSF requires no shielding and is completely accessible to plant personnel. Prior to initial use, the new fuel storage racks and modules are inspected to ensure the absence of any binding using a dummy assembly. For each cell, the dummy assembly is inserted and removed. Thereafter, the cells are periodically inspected.

9.1.1.5 Instrumentation Application

As described in Section 12.3.4, two area radiation monitors are provided near the NFSF which will provide a distinct audible and visual alarm to alert personnel in the vicinity of the need to evacuate. The monitors provide a hi-hi radiation alarm at 15 mR/hr which will give prompt warning of high radiation if accidental criticality occurs. These monitors are provided in accordance with GDC-63 and 10 CFR 70.24.

Criticality is precluded from occurring, however, by design and proper operation of the fuel handling system, as described in Section 9.1.4.

9.1.2 SPENT FUEL STORAGE

A spent fuel storage facility (SFSF) is located within the fuel building and provides onsite storage for spent fuel elements. Spent fuel storage racks are located in the fuel storage pool, which is constructed of reinforced concrete with a stainless steel lining and is an integral part of the fuel building. The fuel storage pool consists of the spent fuel pool and the cask loading pool. The fuel storage pool provides a cooling and shielding medium for the spent fuel. The facility provides protection for spent fuel assemblies under conditions such as tornadoes, earthquakes, and flooding and provides an efficient method for safe and reliable fuel handling operations within the fuel storage pool.

The Independent Spent Fuel Storage Installation (ISFSI) is another location where spent fuel is stored in addition to the fuel storage pool and provides interim dry storage of fuel assemblies that meet specific selection criteria. Irradiated fuel assemblies are stored in specially designed canisters and stored in underground modules, which provide passive cooling and shielding.

9.1.2.1 Design Bases

The SFSF is safety related, and is required to ensure a subcritical array during all normal, abnormal, and accident conditions. It also provides a shielding and cooling medium for the spent fuel.

The principle design bases of the ISFSI are prescribed in the HI-STORM UMAX Certificate of Compliance (CoC) and HI-STORM UMAX FSAR (Docket No. 72-1040). Refer to the Callaway 10 CFR 72.212 Evaluation Report for additional details regarding dry fuel storage system design bases.

9.1.2.1.1 Safety Design Bases

SAFETY DESIGN BASIS ONE - The SFSF is capable of withstanding the effects of natural phenomena, such as earthquakes, tornadoes, floods, and external missiles (GDC-2).

SAFETY DESIGN BASIS TWO - The SFSF is designed to maintain structural integrity after an SSE to perform its intended function following a postulated hazard, such as fire, internal missiles, or pipe break. The SFSF uses the design and fabrication codes commensurate with Category I structures and the seismic category assigned by Regulatory Guide 1.29 (GDC-3 and 4).

SAFETY DESIGN BASIS THREE - Components of this system are not shared with other units (GDC-5).

SAFETY DESIGN BASIS FOUR - The fuel storage pool is designed to maintain fuel assemblies in a subcritical array with $k_{eff} \leq 0.95$ when fuel assemblies are inserted into prescribed locations (GDC-62).

SAFETY DESIGN BASIS FIVE - The fuel handling area and equipment are designed to prevent a drop of an unacceptable object into the fuel storage pool. The SFSF is designed to prevent the loss of cooling water within the pool that could uncover the stored fuel or prevent cooling capability. A redundant seismic Category I emergency makeup water supply is provided. The fuel building is a controlled air leakage facility.

SAFETY DESIGN BASIS SIX - The spent fuel storage racks are designed for the following loads and combinations thereof:

a. Dead loads

b. Live loads (fuel assemblies)

c. Crane uplift load (the spent fuel pool bridge crane - 2 tons)

d. Safe shutdown earthquake loads

e. Operational basis earthquake loads

f. Thermal loads

g. Fuel assembly drop load

SAFETY DESIGN BASIS SEVEN - The SFSF is designed to meet the requirements of 10 CFR 73.55 and 10 CFR 73.60, which require physical protection of special nuclear material while in storage.

SAFETY DESIGN BASIS EIGHT - The spent fuel racks are constructed so as to preclude insertion of spent fuel assemblies into other than prescribed storage locations. If a fuel assembly is accidentally lowered or dropped onto the top of the racks or into the annular space between the spent fuel racks and the pool wall, subcriticality is maintained in all cases with a shutdown margin of at least 0.05 ($k_{eff} \leq 0.95$).

SAFETY DESIGN BASIS NINE - The SFSF is monitored for evidence of criticality in compliance with GDC-63 and 10 CFR 70.24.

SAFETY DESIGN BASIS TEN - The capability to inspect the SFSF is provided (GDC-61).

9.1.2.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - Shielding for the SFSF is sufficient to prevent exposure of the plant personnel to radiation levels greater than 2.5 mrem/hr during normal operations and 10 mrem/hr during fuel handling operations. Gaseous radioactivity above the spent fuel pool is maintained below the limits, as defined in Table 1, Column 1 of Appendix B to 10 CFR 20.

POWER GENERATION DESIGN BASIS TWO - A leak chase and collection system is provided for the detection of leaks in the spent fuel pool liner plate.

POWER GENERATION DESIGN BASIS THREE - Borated demineralized reactor makeup water is used to fill and to supplement water inventory in the spent fuel pool, but boration is not essential for maintaining the subcriticality of the stored fuel assemblies. An alternate source of makeup water is supplied from the refueling water storage tank.

POWER GENERATION DESIGN BASIS FOUR - Fuel handling devices have provisions to avoid dropping or jamming of fuel assemblies and to avoid applying or carrying improper loads during the transfer operation.

POWER GENERATION DESIGN BASIS FIVE - Cranes and hoists used to lift spent fuel have a maximum lift height so that the minimum required depth of water is maintained for shielding. In addition to crane and hoist limitations, a long-handled tool is utilized when handling spent fuel.

9.1.2.2 <u>Facilities Description</u>

The spent fuel pool provides storage space for irradiated spent fuel. The spent fuel pool is a reinforced concrete structure with a stainless steel liner having a normal water volume of approximately 55,260 cubic feet (413,400 gallons). Borated water is used for

filling the spent fuel pool. Figures 1.2-20 through 1.2-22 depict the storage facility. Figure 9.1-2 is a possible fuel storage rack arrangement. See Table 9.1-2 for design data for the fuel storage pool.

When Callaway received its low power operating license in June 1984, the spent fuel pool was authorized to store no more than 1344 fuel assemblies to be located in 12 spent fuel storage racks in the spent fuel pool. With the NRC approval of the Callaway fuel storage pool rerack amendment in 1999, and with the completion of the rerack modification to the spent fuel pool, Callaway's expanded total fuel storage space is increased to a capability to store 2642 fuel assemblies. The modification replaced the original 12 fuel storage racks with 15 high density storage racks in the spent fuel pool and created an additional capability to add three high density storage racks within the cask loading pool during a future campaign. The three high density racks within the cask loading pool would be capable of storing 279 fuel assemblies.

Under the high density storage design, the fuel storage pool can be defined as a Mixed Zone Three Region (MZTR) storage configuration. Fuel storage configuration patterns are setup using administrative controls to establish storage areas specifically designated for low burnup fuel, including fresh (unburned) fuel. Selected configurations ensure that a full core discharge can be accommodated with some allowance for other fuel assemblies that could also require Region 1 storage. Cells reserved for storage of fresh fuel, and spent fuel without any burnup limitations is designated as Region 1. Region 2 and 3 cells have associated minimum burnup requirements for unrestricted fuel storage. The MZTR storage configurations are described in Appendix 9.1A. As an alternative to MZTR storage, Region 1 fuel storage may be accomplished in a checkerboard pattern without any enrichment/burnup restrictions.

The new racks have a closer assembly to assembly spacing to allow for more fuel storage capability. The rack modules are designed as cellular structures such that each fuel assembly has a square opening with conforming lateral support and a flat horizontal bearing surface. The design maximizes structural integrity while minimizing inertial mass. Each rack module is supported by four legs which are remotely adjustable. Therefore, the racks can be made vertical and the top of the racks can easily be made co-planar with each other. The rack module support legs are engineered to accommodate undulations in the pool floor flatness. A bearing pad is interposed between the rack pedestals and the pool liner. It serves to diffuse the dead load of the loaded racks into the reinforced concrete structure of the pool slab. The composite box subassembly, baseplate, and support legs constitute the principal components of the rack module.

The rack modules are free-standing and self-supporting. They are primarily made from Type 304L austenitic stainless steel in a prismatic array interconnected through longitudinal welds. They are separated by a gap of approximately 1.5 inches from one another. Along the pool walls, a nominal gap is provided which varies for each wall. The minimum cell to wall dimension is ¾ inches and the maximum nominal dimension is 7.57 inches.

The racks contain Boral as an active neutron absorber. The Boral provides fixed neutron absorbtion for primary reactivity control in the high density racks. The Boral absorbers in the racks have been sized to sufficiently shadow the active fuel height of all fuel assembly designs stored in the pool.

The criticality analysis (including the associated assumptions and input parameters) given in Appendix 9.1A shows that the spacing between fuel assemblies in the storage racks is sufficient to maintain the array, when fully loaded and flooded with nonborated water, in a subcritical condition, i.e., k_{eff} of less than 0.95. This is based upon fuel with a maximum original enrichment of 5.00 weight percent.

Fresh unirradiated fuel assemblies are either stored in the NFSF or in the allowed regions of the MZTR configuration in the fuel storage pool (or both). Appendix 9.1A provides a discussion of the criticality analysis for fresh unirradiated fuel stored wet in the fuel storage pool.

Burnable poison rod assemblies, sources, rod control clusters, thimble plug assemblies and other non-fueled inserts may be stored in the fuel assemblies in the spent fuel pool. Items such as damaged fuel inserts, burnable poison rods, and other debris from fuel reconstitution may be stored in a container located in the cask loading pool.

The fuel storage rack configuration does not prevent accidental lowering or dropping of a fuel assembly across the top of the racks or into the space between the racks and the pool wall. Criticality under these conditions is addressed in Safety Evaluation Eight. To further assure that no fuel can be damaged, each storage cell is designed to prevent any portion of a fuel assembly or core component from extending above the top of the rack. The spent fuel storage racks are also designed to withstand the impact resulting from a falling fuel assembly under normal loading and unloading conditions and are designed to meet seismic Category I requirements. Design, fabrication, and installation of the spent fuel pool racks are based on AISC specifications (see FSAR Table 3.2-1, Note 19). The design of the racks is based on the elastic design method and allowable stresses defined in Part 1 of the AISC specifications. Allowable stresses are expressed as percentages of yield stresses obtained from Section III of the ASME Code.

The structural, seismic, criticality, and thermal hydraulic analyses (including the associated assumptions and input parameters) given in Appendix 9.1A show that the racks are designed so that subcriticality is maintained during all normal, abnormal, or accident conditions.

The rack modules are freestanding on the floor liner plate of the spent fuel pool. Time-history seismic analyses have been performed and demonstrate that no lateral supports from the pool walls or fastenings to the pool floor are required. The supports for the racks are sufficiently large in area to prevent damage to the spent fuel pool liner and floor leakchase system from concentrated loads.

The rack modules are constructed from square tubes which are welded together to form a honeycomb module. Since the tubes are welded to each other, no structural bracing members are required between the tubes. Each storage cell has a hole in or near the bottom and a rectangular opening on the top of the cell to allow cooling water to flow through the storage cell. The size of the openings precludes blockage by any crud accumulations.

Adjacent to the spent fuel pool are two small pools and a washdown pit. One pool is the fuel transfer canal which has a normal water volume of approximately 13,990 cubic feet (104,659 gallons) and is connected to the refueling pool (inside the containment) by the fuel transfer tube. A leaktight gate is provided to separate the spent fuel pool and the fuel transfer canal. This allows the fuel transfer canal to be drained for maintenance of the fuel transfer system mechanisms.

The second pool is the spent fuel cask loading pool, which has a normal water volume of approximately 12,200 cubic feet (91,268 gallons). It is designed for loading spent fuel assemblies into the spent fuel cask. A leaktight gate is provided to separate the spent fuel from the cask loading pit in the event that the cask loading pool is drained. Also located in the cask loading pool is a stainless steel container. The container rests on the pool bottom. The container serves as a repository for miscellaneous fuel assembly items.

When the cask loading pool gate is opened, the cask loading pool becomes part of the spent fuel storage pool. The floor of the cask loading pool is lower than the spent fuel pool which ensures the transfer cask and fuel canister are at the proper elevation to allow for the use of the spent fuel handling tools when loading spent fuel into the fuel canister. The platform, Variable Elevation Cask Staging Pedestal (VECASP), is a free standing component installed on the floor of the cask loading pool. The VECASP houses the transfer cask-fuel canister assembly during fuel loading and unloading operations. The VECASP is composed primarily of stainless steel and is constrained by outriggers designed to ensure stability during seismic events. Additionally, an earthquake mitigation system is installed on the floor of the cask washdown pit to reduce potential rocking of the transfer cask during postulated seismic events. The HERMIT (Holtec Earthquake Mitigator) is comprised of a stainless steel plate and Nylatron base which dissipates energy during a seismic event thereby reducing rocking of the fully loaded transfer cask.

The concrete structures for the refueling pool, spent fuel pool, cask loading pit, and fuel transfer canal are designed in accordance with the criteria for seismic Category I structures contained in Sections 3.7(B) and 3.8. As such, they are designed to maintain leaktight integrity to prevent the loss of cooling water from the pool. In the event of a loss of integrity of the watertight gate, while one of the small pools is drained, a minimum of 10 feet of water is maintained above the top of the fuel. In addition, all piping penetrations into the pool are designed to preclude draining the pool down to an unacceptable limit, as described in Section 9.1.3.

For the purpose of providing an easily decontaminable surface and to provide a construction form for the concrete pour, a liner plate surface which serves no safety function is provided.

The liner plate is fabricated from 1/4-inch 304L stainless steel, which has been hot rolled, annealed, pickled, and then cold rolled to provide a smooth finish. The joint welds are provided with a leakchase system for initial testing and subsequent monitoring of weld integrity. Following installation and testing, a breach of the liner plate (which could result in any significant loss of water through the leakchase system) is not considered credible.

A monitoring system is provided for the leakchase system, as described in Section 9.3.3. Any water collected is directed to the floor and equipment drain system and transferred to the liquid radwaste system for processing.

The liner plate is anchored to the concrete walls by welding to steel angles which are embedded in the concrete. An analysis has been performed which demonstrates that the liner plate will not, as a result of an SSE, break away from the walls and fall on top of the spent fuel racks. Consequently, the liner plate is prevented from either inflicting mechanical damage to the spent fuel or from blocking the flow of cooling water around the fuel. The watertight gates are also seismically designed to preclude their failure during an SSE and falling onto the spent fuel storage racks.

If weld repair of the liner plate is made in the future, the repair will be in accordance with the following:

a. Materials used, including weld rod, will be verified in accordance with ASTM specifications or equivalent

b. Repair procedures will be in accordance with the original fabrication specifications or equivalent

c. Welders will be qualified in accordance with ASME Section IX or equivalent

d. Non-destructive examination of the weld repairs will be in accordance with the original fabrication specification or equivalent

Should repairs be necessary with water in the fuel pool, special procedures may be required and modifications to the above criteria may be required due to the particular circumstances.

The fuel pool cooling and cleanup system functions to limit the fuel storage pool temperature to 170°F during non-refueling plant conditions (determined from a maximum allowable decay heat load of 63.41 MBtu/hr); remove impurities from the water to improve visual clarity; and limit the radiation dose to the operating personnel to 2.5 mrem/hr during non-refueling operations and 10 mrem/hr during refueling operations. A

description of the fuel storage pool cooling and cleanup system is provided in Section 9.1.3.

During fuel handling operations, a controlled and monitored ventilation system removes gaseous radioactivity from the atmosphere above the spent fuel pool and processes it through HEPA and charcoal adsorber units to the unit vent. Refer to Section 9.4.2 for fuel building system operation and to Section 11.5 for the process ventilation monitor.

Section 9.1.4 discusses the load-bearing capability of all of the cranes serving the SFSF. Section 9.1.4 also provides an evaluation which demonstrates that the maximum uplift force is due to the spent fuel pool bridge crane and the maximum impact load that is due to a dropped fuel assembly. The racks are designed to withstand these loads with no increase in k_{eff}.

[redacted]

The HI-STORM UMAX FSAR contains information on the HI-STORM UMAX storage system generic design, operation, maintenance, safety analysis, and compliance with 10 CFR 72 requirements for cask design. License conditions for the HI-STORM UMAX storage system can be found in the HI-STORM UMAX Certificate of Compliance (CoC) and the Callaway 10 CFR 72.212 Evaluation Report.

The first phase of the UMAX System is designed to contain a total of forty-eight (48) VVMs. Each VVM is designed to contain an MPC capable of holding up to thirty-seven (37) spent fuel assemblies. A low profile transporter is used to transfer the loaded MPCs contained within the HI-TRAC VW from inside the Fuel Building out to the transfer pad. A Vertical Cask Transporter (VCT) is used for moving the loaded HI-TRAC VW/MPC from the transfer pad to the ISFSI. The ISFSI site includes space for an expansion that could accomodate an additional 96 VVMs, should this be required in the future.

Withheld per RIS 2015-17

9.1.2.3 Safety Evaluations

The safety evaluations given below correspond to the safety design bases in Section 9.1.2.1.1.

SAFETY EVALUATION ONE - The FSF is located in the fuel building. The fuel building is designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other appropriate natural phenomena. Sections 3.3, 3.4, 3.5, 3.7(B), and 3.8 provide the bases for the adequacy of the structural design of these buildings.

SAFETY EVALUATION TWO - The FSF is designed to remain functional after an SSE. Appendix 9.1A provides the design loading conditions that were considered. Sections 3.5, 3.6, and 9.5.1 provide the hazards analyses to assure that the facility is properly protected.

SAFETY EVALUATION THREE - The Callaway Plant has an FSF capable of ultimate storage of approximately 2642 fuel assemblies.

SAFETY EVALUATION FOUR - The criticality analyses described in Appendix 9.1A demonstrate that the MZTR loading configuration or alternate Region 1 checkerboard pattern configuration satisfies the subcriticality condition, assuming fresh fuel of up to 5.0 weight percent enrichment with sixteen IFBAs (4.6 weight percent without IFBAs) and unborated water in the pool. Procedures and precautions described in Appendix 9.1A will be employed to ensure that each fuel assembly has achieved an acceptable burnup as indicated on Figure 9.1A-27 before it is stored in the fuel storage pool.

SAFETY EVALUATION FIVE - As described in Section 9.1.2.2, the spent fuel is stored within a concrete pool which has no penetrations which can result in an unacceptable loss of water. As described in Section 9.1.3, a system provides cooling and emergency makeup water for the spent fuel pool. Section 9.4.2 describes the ventilation system provided for the fuel building. Table 9.1-3 indicates compliance with Regulatory Guide 1.13 positions.

SAFETY EVALUATION SIX - The structural, seismic, criticality, and thermal-hydraulic analyses provided in Appendix 9.1A demonstrate that the spent fuel storage racks are designed to withstand normal, abnormal, and accident conditions without causing a decrease in the degree of subcriticality. Section 9.1.4 evaluates the bases for external loads on the spent fuel racks. The probability of a dropped mass accident occurring is remote because of the safe handling features described in Section 9.1.4.

SAFETY EVALUATION SEVEN - The spent fuel is stored within a reinforced concrete wall pool in the fuel building. The security measures taken for the protection of the new and spent fuel against industrial sabotage and theft are discussed in Section 13.6 of the Site Addenda.

SAFETY EVALUATION EIGHT - Criticality analyses, described in Appendix 9.1A, show that if a fuel assembly is dropped on top of the racks or into the gap between the racks and the pool wall, the subcriticality criteria are maintained. The worst geometric configuration is for a fuel assembly to be upright in the gap between the racks and the pool wall and immediately alongside a fuel assembly in the storage racks. If it is assumed that all fuel assemblies are new fuel and the pool water is unborated, $k_{eff} \leq 0.95$.

SAFETY EVALUATION NINE - As described in Section 9.1.2.5, a monitoring system is provided to initiate an audible alarm if high radiation from an accidental criticality occurs.

SAFETY EVALUATION TEN - Access to the SFSF is provided for periodic inspection as shown in Figures 1.2-20 through 1.2-22.

9.1.2.4 Tests and Inspections

The spent fuel storage racks will be shop tested by insertion of a dummy assembly which is 0.17 inch wider than an actual fuel assembly to ensure there is no significant resistance.

9.1.2.5 Instrumentation Application

As described in Section 12.3.4, two area radiation monitors are provided near the FSF which will provide a distinct audible and visual alarm to alert personnel in the vicinity of the need to evacuate. The monitors provide a hi-hi radiation alarm at 15 mR/hr which will give prompt warning of high radiation if accidental criticality occurs. These monitors are provided in accordance with GDC-63 and 10 CFR 70.24.

Criticality is precluded from occurring, however, by design and proper operation of the fuel handling system, as described in Section 9.1.4.

9.1.3 FUEL POOL COOLING AND CLEANUP SYSTEM

The fuel pool cooling and cleanup system (FPCCS) is designed to maintain the spent fuel pool water temperature below prescribed limits by removing decay heat generated by stored spent fuel assemblies and to remove impurities from the refueling pool water, the spent fuel pool water, the transfer canal water, and the water in the cask loading pool in order to ensure optical clarity and to limit the concentration of specific activity in the water. This section describes the FPCCS. There are no shared systems on multiple-unit plants.

The FPCCS consists of three subsystems:

a. Fuel pool cooling system

b. Fuel pool cleanup system

c. Fuel pool surface skimmer system

Each of these subsystems has specific functions and design bases.

9.1.3.1 Design Bases

9.1.3.1.1 Safety Design Bases

The portion of the FPCCS associated with the cooling of spent fuel is safety related.

SAFETY DESIGN BASIS ONE - The safety-related portion of the FPCCS is protected from the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, and external missiles (GDC-2).

SAFETY DESIGN BASIS TWO - The FPCCS is designed to remain functional after an SSE and to perform its intended function following the postulated hazards of fire, internal missiles, or pipe break (GDC-3 and 4).

SAFETY DESIGN BASIS THREE - Safety functions can be performed, assuming a single active component failure coincident with the loss of offsite power. Components of this system are not shared with other units (GDC-5 and 44).

SAFETY DESIGN BASIS FOUR - The active components are capable of being tested during plant operation. Provisions are made to allow for inservice inspection of components at appropriate times specified in the ASME Boiler and Pressure Vessel Code, Section XI (GDC-45 and 46).

SAFETY DESIGN BASIS FIVE - The safety-related portions of the FPCCS use the design and fabrication codes consistent with the quality group classification assigned by Regulatory Guide 1.26 and the seismic category assigned by Regulatory Guide 1.29. The power supply and control functions are in accordance with Regulatory Guide 1.32.

SAFETY DESIGN BASIS SIX - The capability to isolate components or piping is provided so that the FPCCS's safety function will not be compromised. This includes isolation of components to deal with leakage or malfunctions and to isolate nonsafety-related portions of the FPCCS (GDC-44).

SAFETY DESIGN BASIS SEVEN - The containment isolation valves in the system are selected, tested, and located in accordance with the requirements of GDC-54 and 56 and 10 CFR 50, Appendix J, Type C testing.

SAFETY DESIGN BASIS EIGHT - The fuel pool cooling system maintains the spent fuel pool water temperature below 170ºF, considering the maximum decay heat generation rate resulting from the maximum anticipated spent fuel inventory with the maximum anticipated fuel burnup (GDC-44 and 61 and Regulatory Guide 1.13).

SAFETY DESIGN BASIS NINE - System piping is arranged so that loss of piping integrity or operator error does not result in draining of the spent fuel pool below a minimum depth above the stored fuel to ensure sufficient cooling media for cooling the stored spent fuel (Regulatory Guide 1.13).

SAFETY DESIGN BASIS TEN - Redundant seismic Category I makeup water supplies from the essential service water system are provided to ensure adequate makeup capability.

SAFETY DESIGN BASIS ELEVEN - A monitoring system is provided for the FPCCS to detect conditions that could result in the loss of decay heat removal capabilities (GDC-63).

9.1.3.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - The fuel pool cooling system is comprised of two cooling trains, each of which limits the fuel storage pool water temperature to a maximum of 140°F during a partial offload and 170°F during a full core offload. Assumptions and heat loads for both design conditions are given in Table 9.1-4.

POWER GENERATION DESIGN BASIS TWO - The fuel pool cleanup and surface skimmer systems maintain the optical clarity of the pool water so that fuel handling operations are not hampered by limited visibility.

POWER GENERATION DESIGN BASIS THREE - The fuel pool cleanup system limits the fission and corrosion product concentrations in the refueling pool water, the transfer canal water, and the fuel storage pool water to permit operator access to the spent fuel storage area and for fuel handling operations.

POWER GENERATION DESIGN BASIS FOUR - The fuel pool cleanup system contains two pumps and two filters to allow for continuous system operation at a reduced capacity during filter cartridge changing and pump maintenance.

POWER GENERATION DESIGN BASIS FIVE - The fuel pool cleanup system provides the means for filtering and demineralizing the contents in the refueling water storage tank (RWST).

9.1.3.2 <u>System Description</u>

9.1.3.2.1 General Description

The FPCCS shown in Figure 9.1-3 consists of two cooling trains, a cleanup loop, and a surface skimmer loop. The system design parameters are given in Table 9.1-4.

9.1.3.2.1.1 Fuel Pool Cooling System

The fuel pool cooling system consists of two 100-percent-capacity cooling trains for the removal of decay heat generated by irradiated fuel stored in the spent fuel pool. Each train consists of a horizontal centrifugal pump, a shell and U-tube heat exchanger, a strainer, manual valves, and the instrumentation required for system operation. The fuel pool cooling heat exchangers are serviced by the component cooling water system on the shell side with remote manual-operated isolation valves provided.

Spent fuel is placed in the fuel storage pool during a refueling sequence, and is stored there until it is shipped offsite. During a partial offload, up to approximately half of the core fuel assemblies are transferred to the fuel storage pool. The entire core may be transferred to the fuel storage pool during a full core-offload. The decay heat generated is transferred from the fuel pool cooling system through the fuel pool cooling heat exchangers to the component cooling water system.

[redacted]

The normal non-safety related source of makeup water to the fuel storage pool is the reactor makeup water system. An alternate non-safety related source of makeup water is the RWST via either of the fuel pool cleanup pumps. If the reactor makeup water system and RWST are unavailable, the ESW system supplies redundant, safety-related sources of makeup water to the fuel storage pool. Hose fittings are also provided to allow emergency makeup to the fuel storage pool from alternate non-safety related sources through diverse and isolable FPCCS flowpaths.

Boron addition to the fuel storage pool is normally accomplished by supplying borated water from the boric acid tanks via the boric acid blender. Boron may also be added by using the RWST as the source of makeup water to the fuel storage pool.

All makeup and boron addition operations require manual action. Isolation of nonsafety-related portions of the FPCCS is a manual action.

An FPCCS leak is detected when an abnormally high amount of makeup water is required for the fuel storage pool. Leakage is also detected by the floor drain system, as described in Section 9.3.3. Once a significant leak is found, the affected item will be isolated and repaired.

9.1.3.2.1.2 Fuel Pool Cleanup System

The fuel pool cleanup system contains two inline centrifugal pumps and two filters in parallel, a mixed bed demineralizer, and a wye-type strainer. The pumps and filters are designed for 50 percent of the system capacity, and the demineralizer and strainer are designed for 100-percent system capacity. The demineralizer removes ionic corrosion impurities and fission products. The filters are provided to remove particulate matter which would have otherwise entered the demineralizer, and the wye strainer downstream of the demineralizer removes resin fines which may be released from the resin bed.

The fuel pool cleanup system provides the capability for purification of the water in the fuel storage pool, the transfer canal, the refueling pool, and the RWST. The water chemistry specifications are given in Table 9.2-15.

The fuel pool cleanup pump design is based upon both fuel pool cleanup pumps running. One spent fuel pool volume will be processed per day. The design flow rate allows one volume change of the RWST contents in less than 25 hours, or the contents of the refueling pool in less than 22 hours.

9.1.3.2.1.3 Fuel Pool Surface Skimmer System

Surface debris is removed from the spent fuel pool, the fuel transfer canal, and refueling pool by a surface skimmer system. This system is comprised of surface intakes containing float-type strainers positioned just below the water surface.

Lines from both pools and the fuel transfer canal are tied into a common header containing a pump and filter which discharges back into the spent fuel pool or refueling pool.

9.1.3.2.2 Component Description

FPCCS component design parameters are given in Table 9.1-5. Codes and standards applicable to the FPCCS are listed in Tables 3.2-1 and 9.1-5. The FPCCS is designed and constructed in accordance with the following quality group requirements: containment penetrations are quality group B, the separate and redundant cooling loops are quality group C, and the cleanup and skimmer loops are quality group D. The quality group B and C portions are designed to seismic Category I criteria.

Fuel Pool Cooling Pumps - The pumps are 100-percent-capacity, horizontal/centrifugal units. All wetted surfaces are austenitic stainless steel. Each pump takes suction from the spent fuel pool via separate suction lines. Each pump is sized to include an additional 5-percent margin on flow at the design head to accommodate normal degradation of performance due to impeller wear.

Fuel Pool Skimmer Pump - The inline centrifugal pump takes suction from movable surface skimmers, circulates the water through a pool surface strainer and a high

efficiency filter, and returns it to the spent fuel pool. All wetted surfaces of the pump are austenitic stainless steel.

Fuel Pool Cleanup Pumps - These inline centrifugal pumps are used to circulate spent fuel pool and refueling pool water through the fuel pool cleanup filters, demineralizer, and wye strainer for removal of particulate and ionic impurities. Each pump is designed to provide 50 percent of the design flow in the loop. All wetted parts of the pumps are austenitic stainless steel. The contents of the RWST may also be circulated through the cleanup loop, using these pumps.

Fuel Pool Cooling Heat Exchangers - The heat exchangers are the shell and U-tube type. Fuel pool water circulates through the tubes while component cooling water circulates through the shell. Each of the two heat exchangers is sized for 100 percent of the design heat load.

Fuel Pool Cleanup Demineralizer - A flushable, mixed bed demineralizer is used to provide adequate fuel pool water purity for Zone B access of plant personnel to the pool working areas. The demineralizer is equipped with a full flow bypass line which allows for system operation without the demineralizer (filters only) should water purity requirements permit. This demineralizer is also used to purify the contents of the RWST.

Fuel Pool Cleanup Filters - Two filters in parallel, each sized at 50 percent of design flow in the cleanup loop, are located in the purification train, upstream of the demineralizer, to prevent possible particulates from being passed to the demineralizer.

Fuel Pool Skimmer Filter - The fuel pool skimmer filter is used to remove particles which are swept from the fuel pool water surface and not removed by the basket strainer in the floating skimmer.

Fuel Pool Strainers - A strainer is located in each fuel pool cooling pump suction line to prevent the introduction of relatively large particles which might otherwise foul the fuel pool cooling heat exchangers or damage the fuel pool cooling pumps.

Fuel Pool Skimmer Strainer - A strainer is located in the floating skimmer inlet to remove relatively large debris from the skimmer process flow.

Fuel Pool Cleanup Strainer - A wye-type strainer is provided downstream of the fuel pool cleanup demineralizer to prevent the entry of resin fines into the fuel pool and to trap any resin beads released in the event of retention element failure.

Valves - Manual stop valves are used to isolate equipment and manual throttle valves to provide flow control. Valves in contact with fuel pool water are austenitic stainless steel. Remote manually operated isolation valves are provided in the CCW line from each fuel pool cooling heat exchanger.

Piping - All piping in contact with the fuel pool water is austenitic stainless steel. The piping is welded, except where flanged connections are used to facilitate maintenance.

9.1.3.2.3 System Operation

9.1.3.2.3.1 Fuel Pool Cooling System

Normal operations of the fuel pool cooling system are manual and intermittent. The system is started, operated, and secured locally as required to maintain the water temperature below 140°F in the fuel storage pool and to minimize the starting and stopping of a fuel pool cooling pump. During refueling, the refueling pool and the reactor core are cooled by the RHR system, as described in Section 5.4.7. The fuel pool cooling system is used only for removal of the decay heat generated by the irradiated fuel in the fuel storage pool.

The fuel storage pool water will be borated to a concentration of at least 2,165 ppm.

Boron addition to the fuel storage pool is normally supplied from the boric acid tanks via the boric acid transfer pumps and the boric acid mixing tee, using a feed-and-bleed process. Boron may also be added to the pool water by supplying borated water from the RWST via the fuel pool cleanup pumps. These operations require manual action by the operator.

Makeup water to the fuel storage pool is normally provided by the reactor makeup water system via a manually operated valve. Makeup water may also be supplied from the RWST via the fuel pool cleanup pumps if the reactor makeup water system is unavailable. These makeup supplies compensate for normal evaporative losses from the fuel storage pool. The flow rate to the fuel storage pool is locally controlled by a manually operated valve.

In the event that a complete irradiated core is unloaded from the reactor and stored in the fuel storage pool, the fuel pool cooling system has the capability to maintain the fuel storage pool water temperature at or below 170°F with only one cooling train operating (see Table 9.1-4).

Following a loss of normal power, without a loss-of-coolant accident (LOCA), the fuel pool cooling pumps can be switched manually to the standby power system to maintain cooling of the fuel storage pool.

Following a LOCA with loss of offsite power, the fuel pool cooling pumps trip, and cooling of the fuel storage pool is interrupted. Post-LOCA, prior to start of the recirculation phase, the operator will isolate the component cooling water flow to the fuel pool heat exchangers after establishing flow to the RHR heat exchangers. Flow is reestablished to the fuel pool heat exchangers after approximately 4 hours, when sufficient excess capacity exists in the CCWS. When the FPCCS is reestablished, the fuel pool cooling

pumps are manually loaded to the Class 1E power source, and CCW flow is established to at least one of the fuel pool cooling heat exchangers.

The bulk fuel storage pool and in-cell thermal hydraulic analysis (including the associated assumptions and input parameters) given in Appendix 9.1A supports the data provided in Table 9.1-4.

Redundant, safety-related sources of makeup water are supplied to the fuel storage pool by the ESW system via manually operated valves. Hose fittings are also provided to allow emergency makeup to the fuel storage pool from alternate non-safety related sources. These sources of makeup are to be used only when the reactor makeup water system and RWST are not available to supply makeup to the fuel storage pool.

During normal shutdown of the reactor, the RHR system is utilized to remove core decay heat, as described in Section 5.4.7. At 4 hours after shutdown, the RHR heat exchanger represents sufficient available CCW system duty to require terminating CCW flow to the FPCCS heat exchangers. Under this mode of operation, the fuel storage pool temperature is allowed to rise to a maximum of 160°F, at which point flow is reestablished to the FPCCS heat exchangers and sufficient excess CCWS capacity exists to handle the fuel storage pool duty.

9.1.3.2.3.2 Fuel Pool Cleanup System

Normal fuel pool cleanup system operation is manual and intermittent. The system is started, operated, and secured locally, as required, to maintain optical clarity and to limit ionic corrosion and fission product concentration in the fuel storage pool and the refueling pool. During normal system operation, both fuel pool cleanup pumps can be run to obtain maximum system capability. Samples are periodically taken from the cleanup loop to determine the quality of the water.

During a refueling, after the refueling pool is filled with borated water from the RWST, the fuel pool cleanup pumps take suction from the refueling pool and transfer the water through both fuel pool cleanup filters and the fuel pool cleanup demineralizer and back to the refueling pool. The cleanup of the refueling pool by the fuel pool cleanup system is augmented by the CVCS via the RHR system to expedite the cleanup process.

During this time, items removed from the refueling pool are sprayed down using unborated water. This is performed to facilitate the decontamination of those items. Administrative controls will prevent diluting the pool below acceptable boron concentration limits.

These operations are continued during the entire refueling process to maintain water clarity for refueling and to minimize the radiation dose to operators. Following transfer of the irradiated fuel to the fuel storage pool, the cleanup lines to the refueling pool are manually isolated and drained, and fuel storage pool cleanup is initiated as required.

After the refueling pool is drained to the RWST, the fuel pool cleanup system is isolated from the fuel storage pool, and the RWST is manually aligned for cleanup by the fuel pool cleanup filters and demineralizer, via both fuel pool cleanup pumps.

Upon high differential pressure or indication by manual sampling that the demineralizer resins are spent, the demineralizer resins are transferred to the solid radwaste system, as described in Section 11.4. Upon high differential pressure across the fuel pool cleanup or skimmer filters, that filter is isolated, and the cartridge is replaced by the filter handling system of the solid radwaste system, as described in Section 11.4.

The fuel pool cleanup system is manually secured (or the demineralizer is bypassed) when the fuel pool water temperature exceeds 140°F to prevent damage to the fuel pool cleanup system resin beds.

9.1.3.2.3.3 Fuel Pool Surface Skimmer System

The fuel pool surface skimmer system is aligned and operated, as required, to clean the refueling pool water surface and/or the fuel storage pool water surface. All operations require manual operator action.

9.1.3.3 <u>Safety Evaluation</u>

The safety evaluations given below correspond to the safety design bases in Section 9.1.3.1.1.

SAFETY EVALUATION ONE - The safety-related portions of the FPCCS are located in the reactor, auxiliary, and fuel buildings. These buildings are designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other appropriate natural phenomena. Sections 3.3, 3.4, 3.5, 3.7(B), and 3.8 provide the bases for the adequacy of the structural design of these buildings.

SAFETY EVALUATION TWO - The safety-related portions of the FPCCS are designed to remain functional after a safe shutdown earthquake. Sections 3.7(B).2 and 3.9(B) provide the design loading conditions that were considered. Sections 3.5, 3.6, and 9.5.1 provide hazards analyses to assure that safe shutdown, as outlined in Section 7.4, can be achieved and maintained.

SAFETY EVALUATION THREE - Complete redundancy is provided and, as indicated by Table 9.1-6, no single failure will compromise the system's safety functions. All vital power can be supplied from either onsite or offsite power systems, as described in Chapter 8.0.

SAFETY EVALUATION FOUR - The FPCCS is initially tested with the program given in Chapter 14.0. Periodic inservice functional testing is done in accordance with Section 9.1.3.4.

Section 6.6 provides the ASME Boiler and Pressure Vessel Code Section XI requirements that are appropriate for the FPCCS.

SAFETY EVALUATION FIVE - Section 3.2 delineates the quality group classification and seismic category applicable to the safety-related portion of this system and supporting system. Section 9.1.3.2.2 shows that the components meet the design and fabrication codes given in Section 3.2. All the power supplies and the control functions necessary for safe function of the FPCCS are Class 1E, as described in Chapters 7.0 and 8.0.

SAFETY EVALUATION SIX - Section 9.1.3.2.1.1 describes provisions made to identify and isolate leakage or malfunction and to isolate the affected portion of the system.

SAFETY EVALUATION SEVEN - Sections 6.2.4 and 6.2.6 provide the safety evaluation for the system containment isolation arrangement and testability.

SAFETY EVALUATION EIGHT - The maximum decay heat generation rate that can be removed is governed by the capabilities of the Spent Fuel Pool Cooling System. The maximum decay heat loading was determined to be 63.41 x 10^6 Btu/hr as discussed in Appendix 9.1A.5.5 (see also Table 9.1-4). Under this peak heat load, one fuel pool cooling train can maintain the fuel storage pool water temperature at or below 170°F. Cycle-specific decay heat analyses and administrative controls ensure that the maximum pool thermal loading limit is not exceeded.

The fuel pool cooling system is controlled manually. Assuming that one fuel pool cooling train fails, the fuel storage pool is large enough that an extended period of time is required for the water to heat up significantly, if cooling were interrupted. Therefore, there is sufficient time for the operator to manually switch to the backup cooling train. Table 9.1-4 contains the heatup rates for the two design basis conditions. Table 9.1-3 indicates compliance with the Regulatory Guide 1.13 positions.

[redacted]

SAFETY EVALUATION TEN - The redundant seismic Category I essential service water system intertie with the fuel storage pool ensures adequate fuel storage pool makeup water, considering the maximum anticipated evaporation rates of the fuel storage pool water, as given in Table 9.1-4.

SAFETY EVALUATION ELEVEN - As described in Section 9.1.3.5, a monitoring capability is provided to verify fuel storage pool level and bulk temperature.

9.1.3.4 Tests and Inspections

Preoperational testing is discussed in Chapter 14.0.

Provisions are incorporated in the design to allow for periodic starting of the nonoperating pump for verification of the required cooling flowpath. These operations demonstrate the operability, performance, and structural and leaktight integrity of all FPCCS components.

The safety-related components of the system, i.e., pumps, valves, heat exchangers, and piping (to the extent practicable), are designed and located to permit preservice and inservice inspections.

9.1.3.5 Instrumentation Applications

The instrumentation provided for the fuel pool cooling and cleanup system is discussed below. Alarms and indications are provided as noted.

a. Temperature

Instrumentation is provided to measure the temperature of the water in the fuel storage pool and give main control room indication as well as annunciation when normal temperatures are exceeded. Instrumentation is also provided to indicate the temperature of the fuel pool water as it leaves each heat exchanger.

b. Pressure

Instrumentation is provided to measure and give local indication of the pressures in the suction and discharge lines of the fuel pool cooling pumps. Local pressure indication is provided on the discharge of the fuel pool cleanup pumps and fuel pool skimmer pump. Differential pressure instrumentation is also provided at the fuel pool cleanup demineralizer and filters and the fuel pool skimmer filter so that the pressure differential across these components can be determined.

c. Flow

Instrumentation is provided to measure and give local and main control room indication of the flow in the outlet line of the fuel pool cleanup pumps. A low-flow alarm is located in the main control room, in addition to a local low-flow alarm.

Instrumentation is also provided to measure and give local and main control room indication of the flow in the discharge lines of the fuel pool cooling pumps.

d. Level

A Class 1E level switch is provided to protect each fuel pool cooling pump from loss of suction on low water level in the fuel storage pool. Instrumentation is also provided to measure the water level of the fuel storage pool and give local and main control room indication and annunciation of high or low pool levels.

Non-Class 1E wire-guided wave radar level instrumentation is provided to reliably monitor the spent pool water level under adverse environmental conditions resulting from a Beyond Design Basis External Event (BDBEE). The instrumentation consists of two standalone systems with one acting as the primary system and the other as a backup system. Level indications for both systems are located in the Auxiliary Building Hallway Room 1408, providing diverse, wide-range indication of spent fuel pool water level.

9.1.4 FUEL HANDLING SYSTEM

The fuel handling system (FHS) provides a safe means for handling fuel assemblies and control components from the time of receipt of new fuel assemblies to storage or shipment of spent fuel. This includes equipment necessary for reactor vessel servicing.

Design considerations include maintaining occupational radiation exposures ALARA during transportation and handling.

The fuel handling system is composed of cranes, equipment, special fuel handling devices, and a fuel transfer system that are designed to meet the seismic and safety classifications shown in Section 3.2.

The equipment utilized with the fuel handling system during ISFSI loading operations, include the Lift Yoke, Lift Yoke Extension, Variable Elevation Cask Staging Pedestal (VECASP) and Holtec Earthquake Response Mitigator (HERMIT), which are used in conjuction with the HI-TRAC VW transfer cask. The Lift Yoke and Lift Yoke Extension are used during the rigging and lifting of the HI-TRAC VW transfer cask in the Fuel Building. The VECASP, which is located in the cask loading pit, is used to support the HI-TRAC VW transfer cask during loading or unloading operations. The HERMIT, which is located in the cask washdown pit, is also used to support the HI-TRAC VW transfer cask during all sealing or unsealing operations. A description of the HI-TRAC VW transfer cask is provided in the Holtec HI-STORM UMAX FSAR.

9.1.4.1 Design Bases

9.1.4.1.1 Safety Design Bases

The portions of the FHS that are safety related are the containment isolation features of the fuel transfer tube and the crane structural components which prevent falling of major crane components onto fuel assemblies or safe shutdown equipment.

SAFETY DESIGN BASIS ONE - The FHS is protected from the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, and external missiles (GDC-2).

SAFETY DESIGN BASIS TWO - The FHS is designed to remain intact after an SSE or following the postulated hazards of fire, internal missiles, or pipe breaks (GDC-3 and 4).

SAFETY DESIGN BASIS THREE - The FHS components are capable of being tested during plant operation. Provisions are made to allow for inservice inspection and testing of components at appropriate times.

SAFETY DESIGN BASIS FOUR - The FHS is designed and fabricated to codes consistent with the seismic category assigned by Regulatory Guide 1.29 and industry standard specifications.

SAFETY DESIGN BASIS FIVE - The containment isolation provisions for the system are selected, tested, and located in accordance with the requirements of GDC-54 and 10 CFR 50, Appendix J, Type B testing.

SAFETY DESIGN BASIS SIX - The FHS is designed and arranged so that there are no loads which, if dropped, could result in damage, leading to the release of radioactivity in excess of 10 CFR 100 guidelines, or impair the capability to safely shut down the plant. Specific administrative controls for handling of the spent fuel pool transfer gates are addressed in Section 9.1.4.3.

This meets the requirements of Regulatory Guide 1.13, as described in Table 9.1-3.

9.1.4.2 System Description

9.1.4.2.1 General Description

The fuel handling system consists of the equipment needed to refuel the reactor core. Basically, this equipment is composed of cranes, handling equipment, and a fuel transfer system.

The associated fuel handling structures are divided into seven areas. In general, these areas are:

a. The refueling pool

b. The fuel transfer canal

c. The spent fuel pool

d. The cask loading pool

e. The cask washdown pit

f. The new fuel storage vault

g. The new fuel receiving and inspection area

Figures 9.1-4 through 9.1-15 show equipment configurations and the areas of movement of the spent fuel and cask handling cranes.

The new fuel assemblies are removed one at a time from the shipping container utilizing the monorail on the cask handling crane, inspected in the new fuel inspection area, and stored in the new fuel storage racks within the new fuel storage vault.

The new fuel is moved from its storage rack, utilizing the monorail hoist on the cask handling crane, and transferred to the new fuel elevator. The new fuel elevator is used to lower the new fuel assemblies into the cask loading pool. The new fuel is moved from the new fuel elevator, utilizing the spent fuel handling tool with the spent fuel bridge crane, transferred to the upending mechanism located in the transfer canal, and then moved through the fuel transfer tube to the refueling pool where it is handled by the refueling machine.

The fuel transfer system includes a rod cluster control (RCC) storage rack and refueling machine. These facilitate the exchange of control rods between spent fuel and new fuel. The RCC storage rack may be used for temporary storage of new fuel during the refueling operations.

Spent fuel is removed from the reactor with the refueling machine, transferred to the fuel storage pool by the fuel transfer system and the spent fuel pool bridge crane, and deposited in a fuel storage pool rack.

In the fuel storage pool, fuel assemblies are moved by the spent fuel bridge crane. When lifting spent fuel assemblies, a long-handled tool is used to ensure that sufficient radiation shielding is maintained.

After a decay period as defined by the HI-STORM UMAX Certificate of Compliance (CoC), the spent fuel may be removed from the storage racks and transferred to the spent fuel storage canister. The fuel is loaded into the canister while the cask system is in the cask loading pool.

Reactor servicing consists of those operations necessary to support refueling, maintenance, and inservice inspection.

9.1.4.2.2 Component Description

Principal codes and standards applicable to the FHS are listed in Tables 3.2-1 and 9.1-7 (Sheet 2).

REFUELING MACHINE - The refueling machine is a rectilinear bridge and trolley crane with a vertical mast extending down into the refueling pool. The bridge spans the refueling pool and runs on rails set into the pool edges. The bridge and trolley motions are used to position the vertical mast over a fuel assembly in the core. The refueling machine is capable of simultaneous bridge and trolley motion. The hoist controls are interlocked with the bridge and trolley through the control console, so that hoist motion is not allowed at the same time as bridge or trolley motion. A long tube with a pneumatic gripper on the end is lowered from the mast to grip the fuel assembly. The gripper tube is long enough so that the upper end is contained in the mast when the gripper end contacts the fuel assembly. A winch mounted on the trolley raises the gripper tube and fuel assembly up into the mast tube. The fuel is transported to its new position while inside the mast tube.

All controls for the refueling machine are mounted on a console on the trolley. The console is removed during normal plant operation. The console contains a Programmable Logic Controller (PLC) and Personnel Computer (PC). The PLC monitors the refueling machine's speed, position, limit switches, joysticks, etc. and provides interlocks and controls for the refueling machine operation. The PC performs the graphical operator interface for the refueling machine operation. There are sufficient panel meters, indicators, and control switches to safely operate the refueling machine without the PC functioning. Absolute position encoders provide input into the PLC of the refueling machine bridge, trolley, and hoist positions. The bridge and trolley are positioned in relation to a grid pattern referenced to the core. Bridge and trolley positions are also indicated by a pointer-ruler system.

The outer mast is mounted on the trolley structure on a support bearing that allows rotation of the mast to allow a fuel assembly that is not properly oriented with the core position to be picked up and rotated into proper alignment. In the event a fuel assembly must be turned 90 degrees or 180 degrees, the stops can be disconnected and the mast turned manually. With the mast rotated from normal operating position, the hoist is run at slow speed.

Fuel assemblies can be placed in the core in only one way relative to the core centerlines. Orientation of the fuel is maintained by the gripper which can engage the fuel only when the relative orientation is correct.

PC monitor graphics and panel meter indications are observed by the operator at the console. The drives for the bridge, trolley, and winch are variable speed. The maximum

speed for the bridge is approximately 60 feet per minute. The trolley and hoist maximum speeds are approximately 30 and 40 feet per minute, respectively. The auxiliary monorail hoist on the refueling machine has an electromagnetic controller to give hoisting speeds of approximately 7 and 22 feet per minute.

PLC interlocks for the bridge and trolley motor drives prevent damage to the fuel assemblies. The hoist also utilizes PLC interlocks, limit switches, and a mechanical stop to prevent a fuel assembly from being raised above a safe shielding depth should the limit switch fail. In an emergency, the bridge, trolley, and winch can be operated manually, using a handwheel on the motor shaft. Suitable restraints are provided between the bridge and trolley structures and their respective rails to prevent derailing.

A conservative design approach is used for all load-bearing parts. The static design load for the crane structure and all lifting components is normal dead and live loads plus three times the fuel weight with a RCC assembly inserted. The design load on the wire rope hoisting cables does not exceed 0.20 times the average breaking strength. Where two cables are used, each is assumed to carry one-half the load.

A single finger on the fuel gripper can support the weight of a fuel assembly and RCC assembly without exceeding the requirements given in Table 9.1-7.

All components critical to the operation of the equipment or located so that parts can fall into the reactor are assembled with the fasteners positively restrained from loosening under vibration.

The refueling machine design includes the following provisions to ensure safe handling of fuel assemblies:

a. Safety interlocks

Operations which could endanger the operator or damage the fuel are prohibited by mechanical or fail-safe electrical interlocks or fail-safe PLC interlocks, or by redundant electrical interlocks. All other interlocks are intended to provide equipment protection and may be implemented either mechanically, by PLC interlocks, or by electrical interlock, not necessarily fail-safe. The refueling machine control system contains numerous electrical, mechanical, and PLC interlocks for limiting the refueling machine’s motion, speed, loads, gripper operation, etc. to ensure the safe movement of fuel assemblies. The interlocks considered critical for safe refueling machine operation are listed below.

1. When the gripper is engaged, the machine cannot traverse between the core and the fuel transfer system unless the guide tube is in its full up position. Bridge and trolley motion are allowed at a slow speed with the gripper engaged and the guide tube not at its full up position when over the core, the rod cluster control change fixture,

or the fuel transfer system to allow for fine positioning of the mast in these areas.

2. When the gripper is disengaged, the machine cannot traverse between the core and the fuel transfer system unless the gripper is withdrawn into the mast. Bridge and trolley motion are allowed at a slow speed with the gripper disengaged and inside the mast when positioned over the core, the rod cluster control change fixture, or the fuel transfer system to allow for fine positioning of the mast in these areas.

3. Vertical motion of the guide tube is permitted only in a controlled area over the reactor (avoiding the vessel guide studs), fuel transfer system, gripper test fixture, gripper emergency disengage plate, or rod cluster control change fixture.

4. Traverse of the trolley and bridge is limited to the areas of item 3 and a clear path connecting those areas.

5. The gripper is monitored by limit switches to confirm operation to the fully engaged or fully disengaged position. An audible and a visual alarm are actuated if both engaged and disengaged switches are actuated at the same time or if neither is actuated. A time delay may be used to allow for recycle time of normal operation.

6. The engaged fuel gripper will not release unless it is in its down position in the core, in the fuel transfer system, rod cluster control change fixture, or gripper test fixture, or gripper test fixture and the weight of the fuel is off the mast.

7. Raising of the guide tube is not permitted if the gripper is disengaged and the load monitor indicates that it is still attached to the fuel assembly.

8. Raising of the guide tube is not permitted if the hoist loading exceeds the setpoint specified in Section 16.9.2.1.

9. Lowering of the guide tube is not permitted if the hoist loading is less than the setpoint specified in Section 16.9.2.1.

10. The guide tube is prevented from rising to a height where there is less than 10 feet of nominal water coverage over the fuel.

11. The guide tube is prevented from lowering completely out of the mast.

12. The guide tube travels only at a controlled maximum speed of about 3 fpm when: a) the bottom of the fuel begins to enter the core, and b) the gripper approaches the top of the core. In addition, the guide tube automatically stops lowering, in these areas and requires acknowledgement from the operator, by releasing the hoist joystick, before proceeding.

13. The fuel transfer system container is prevented from moving unless the engaged gripper is in the full up position or the disengaged gripper is withdrawn into the mast, or unless the refueling machine is out of the fuel transfer zone. An interlock is provided from the refueling machine to the fuel transfer system to accomplish this.

14. The refueling machine gripper has a mechanical interlock which prevents the gripper from incorrectly lifting a fuel assembly. The gripper has (2) alignment pins and (1) index pin to orient the gripper to the top nozzle block of the fuel assembly. There are (4) rotating fingers which are used to lift each fuel assembly. The fingers are locked in the engaged or retracted position by a spring loaded collar. The collar will only move up, allowing the fingers to be moved from the engaged or disengaged position, when the gripper is properly aligned with the nozzle block and lowered on to it. An air cylinder (actuator) operates an actuator tube with a cam follower that moves along a cam surface on the back of the fingers causing them to rotate in (disengaged) and out (engaged).

15. Key-operated bypass switches are provided to bypass the PLC interlocks described above to allow for refueling machine troubleshooting, maintenance, and operation of an inspection camera on the gripper. The bypass switches cause a warning message to be displayed on the PC monitor and a red light to illuminate on the console panel.

b. Bridge and trolley holddown devices

The refueling machine bridge and trolley are both horizontally restrained on the rails by two pairs of guide rollers, one pair at each wheel location on one truck only. The rollers are attached to the bridge truck and contact the vertical faces on either side of the rail to prevent horizontal movement. Vertical restraint is accomplished by antirotation bars located at each of the four wheels for both the bridge and trolley. The antirotation bars are bolted to the trucks and extend under the rail flange. Horizontal and vertical restraints are both adequately designed to withstand the forces and overturning moments resulting from the SSE.

c. Main hoist braking system

The main hoists are equipped with two independent braking systems. A solenoid-release, spring-set electric brake is mounted on the motor shaft. This brake operates in the normal manner to release upon application of current to the motor and set when current is interrupted. The second brake is a mechanically actuated load brake internal to the hoist gear box that engages if the load starts to overload the hoist. It is necessary to apply torque from the motor to raise or lower the load. In raising, this motor cams the brake open; in lowering, the motor slips the brake, allowing the load to lower. This brake actuates upon loss of torque from the motor for any reason and is not dependent on any electrical circuits. Both brakes are rated at 125 percent of the hoist design load.

d. Fuel assembly support system

The main hoist system is supplied with redundant paths of load support so that failure of any component will not result in free-fall of the fuel assembly. Two wire ropes are anchored to the winch drum and carried to a load-equilizing mechanism on the top of the gripper tube. In addition, supports for the equalizing mechanism are backed up by passive restraints to pick up the load in the event of the failure of this primary support.

e. In-mast sipping system

The refueling machine contains an in-mast sipping system for detecting leaking fuel assemblies. The system consists of a series of support bands attached to the stationary mast that hold the injection line in place. The injection line runs down the stationary mast to two nozzles located at the bottom of the mast. The nozzles are used to inject air through fuel assemblies for sampling. Air samples are taken at the top roller assembly on the stationary mast just above the refueling pool water level. Stainless steel hoses run from the injection and suction lines near the top of the mast, through the deck to the control consoles on the refueling machined trolley deck. The control consoles are removed during normal plant operations while the rest of the equipment remains attached to the refueling machine.

During each refueling outage and prior to removing fuel, the gripper and hoist system are load tested to 125 percent of the maximum setting on the hoist overload load limit.

CASK HANDLING CRANE - The cask handling crane is a Crane Manufacturers Association of America (CMAA) No. 70, Class A, indoor electrical overhead traveling bridge crane. The crane utilizes a NOG-1 and NUREG-0554/0612 compliant single-failure proof main hoist and trolley; a non-single failure proof monorail hoist and trolley; along with all the necessary motors, controls, and brakes; and a pendant control station. The crane hoist is rated at 125 tons.

The crane and accessories are used to handle spent fuel shipping casks between trucks, the loading pool, and the washdown pit.

The main hoist, trolley and bridge motors use infinitely variable Variable Frequency Drives (VFDs) to allow for positioning of the crane at desired locations.

The cask handling crane is equipped with a monorail and hoist which is used to transfer new fuel from the new fuel storage vault to the new fuel elevator. The monorail is also used for moving new fuel shipping containers. The monorail hoist is rated at 5 tons. The radio control unit is utilized for controlling the cask handling crane and the monorail hoist.

Under normal use, limit switches and mechanical stops are located to prevent any crane (other than the spent fuel pool bridge crane) from traveling over the spent fuel pool. During scheduled maintenance periods, the cask handling crane is used to provide access over the spent fuel pool, for example, for servicing of light bulbs and fire detectors. During these periods, the rail stops are removed to allow crane travel. These rail stops, which are not heavy loads, are hinged such that they can be rotated out of the path of the cask handling crane. The hinged connections are outside the crane rails and the stops rotate away from the center of the fuel building to allow crane travel. These stops do not require lifting to clear the cask handling crane, but are permanently attached to the crane rail support girder, thus precluding a drop. Administrative procedures are used to control removal and replacement of the interlock and stops and to position the hoist and hook so as not to travel above the pool during use of the cask handling crane above the pool.

The design of the main hoist prevents two blocking, but it also is designed to accommodate two blocking without cutting or crushing the wire ropes. The main hoist also provides for redundant travel limit switches. A primary rotary limit switch on the drum shaft senses both the upper and lower positions of load block travel and stops the motion by de-energizing the hoist controls. The secondary lever-operated power limit switch is tripped by the lower block and directly breaks power to the hoist motor.

Specific data for the cask handling crane travel speeds and lifting capacities are shown on Table 9.1-7.

SPENT FUEL POOL BRIDGE CRANE - The spent fuel bridge crane is a CMAA No. 70, Class B type. The crane is designed to maintain its integrity during an SSE.

The crane consists of a 5-ton-capacity wheeled bridge structure with steel deck walkway, a 2-ton motorized monorail trolley, and a 5-ton manual push-type trolley. The crane has interlocking capabilities with the new fuel elevator, fuel transfer canal gate, and cask loading gate.

The spent fuel bridge crane is used to transport new and spent fuel to and from various locations inside the fuel building. These locations include the new fuel elevator, fuel storage pool racks, spent fuel shipping cask, upending device of the fuel transfer car, and fuel storage pool transfer gates. The handling tools for the new and spent fuel are different to prevent interchanging of the same. The hoist travel and tool length are designed to limit the maximum lift of a fuel assembly to a safe shielding depth.

The 2-ton electric hoist of the crane will be primarily used to transfer spent fuel and new fuel assemblies. Control will be from a pendant station supported from the trolley. A 5-ton manual chain hoist and two safety trolleys are used to move the fuel storage pool transfer gates to and from their normal storage positions (and to and from a location suitable for replacement of the transferable seals, e.g. fuel transfer canal or cask loading pit). The hoists share the same monorail. While moving the transfer gates, the gates are secured by two redundant supports to preclude the dropping of a gate on the fuel storage pool racks.

The spent fuel pool bridge crane has a limited maximum lift height so that the minimum required depth of the water shielding is maintained when the spent fuel is handled. This is accomplished by the use of limit switches.

Geared-type upper and lower limit switches are used in the control circuit of the electric hoist system of the spent fuel pool bridge crane. In addition to the geared-type limit switches, a weight-operated hoist upper limit switch is used in the electric hoist system of the spent fuel pool bridge crane. The two types of hoist upper limit switches are redundant and independent. If the geared-type limit switch were to fail, the weight-operated limit switch would cut off power to the hoist, thus preventing vertical motion of the lifting block and the occurrence of a two-blocking event.

Specific data pertaining to the travel speeds are shown on Table 9.1-7.

CONTAINMENT BUILDING POLAR CRANE - The polar crane is a CMAA No. 70, Class C type.

The containment has a 260/25-ton polar crane which is used, in conjunction with the various lifting rigs, to remove the reactor vessel head, the reactor vessel upper internals, and the lower internals. The 25-ton auxiliary hook on the polar crane, in conjunction with strategically located 3-ton-capacity jib cranes, is used for routine maintenance and inservice inspection. The crane is controlled from its bridge-mounted cab, a portable cab, or a portable radio control unit. The polar crane is designed to maintain its integrity with load during an SSE.

The polar crane bridge is equipped with seismic restraints (snubbers), one in each corner of the crane. Each snubber consists of two wheels, each wheel contained in a frame. The two frames are pinned into a holding frame and thus are able to move with respect to each other. The wheels are retracted up to 3/4" from the face of the girder flange on which the crane rests. In case of a seismic event, the wheels could come in

contact with the girder flange face, while the shock absorbers prevent the crane from moving more than 3/4 of an inch in the horizontal plane. Vertical motion is restrained through the use of upkick lugs on the snubber frame, which project under the girder flange face.

Positive means are also provided to limit motion of the polar crane trolley during a seismic event. Trolley earthquake restraints are provided to limit vertical motion of the trolley. These restraints are attached to both sides of the trolley girders and project under the flanges supporting the rails on which the trolley runs. To help limit horizontal motion of the trolley during a seismic event, rail capture bars are provided.

The main hoist of the polar crane has a micro drive, which enables the operator to move the main hoist hook at a speed of 3 inches per minute. The auxiliary hoist of the polar crane has an "inching" feature, which allows the operator to raise or lower the load at approximately 1/16 of an inch increments.

Geared-type upper and lower limit switches are used in each hoist system of the containment building polar crane. The geared-type limit switch is driven off the hoist drum shaft through an eccentric pin and crank arrangement. As the switch drive shaft rotates, it rotates two cam gears. Cam screws lock the cam wheels to their respective cam gears. Snap switches are actuated when the lobes on their associated cam wheels contact the switch pushers. Snap switches open or close the contacts, thereby breaking or completing the electrical circuit to the hoist motor and holding brake.

In addition to the geared-type limit switches, a weight-operated hoist upper limit switch is used in each hoist system of the containment building polar crane. This assembly is used as a safety-type limit switch or final upper stop to prevent over-travel of the hook block as it approaches its upper limit. Thus, the block and load are prevented from coming into contact with any portion of the trolley, and an unsafe condition is avoided.

The two types of hoist upper limit switches, geared and weight-operated, are redundant and independent. This is to say that if the geared-type limit switch were to fail, the weight-operated limit switch would stop the load block from rising higher and would prevent the occurrence of a two-blocking event.

The polar crane main and auxiliary hooks will be administratively controlled by procedure to prevent travel of potentially damaging loads over the reactor vessel when the upper internals have been removed and fuel is in the reactor vessel except for required reactor vessel servicing activities such as irradiation sample removal. Note that during irradiation sample removal, the loads carried over the vessel are light (less than 300 pounds).

Specific data pertaining to the crane travel speeds and lifting capacity are shown on Table 9.1-7.

FUEL TRANSFER TUBE AND ASSOCIATED COMPONENTS - The fuel transfer system permits the safe underwater transfer of new and spent fuel assemblies between the fuel transfer canal in the fuel building and the refueling pool in the reactor building. Connecting these two areas is the fuel transfer tube which is a steel pipe 20 inches outside diameter and approximately 20 feet long. The pipe is inserted in a sleeve which is embedded in the concrete walls separating the two areas.

Angle rails forming a track and extending from the refueling canal through the transfer tube and into the transfer canal permit the controlled travel of the fuel car. During the fuel transfer operations, the fuel assemblies are supported by the fuel car. Attached to the car is the transfer car container which holds the fuel assembly. This container is a tube and is equipped with a centrally located pivot which allows the fuel assembly to be rotated from a vertical to a horizontal orientation for easier transfer. The fuel transfer car and container assembly travel through the transfer tube as one unit.

Positioned at each end of the transfer tube are mechanical stops and water-activated hydraulic lifting arms which are the mechanisms that allow the fuel assembly to be pivoted. Each hydraulic drive is operated by a CAT pump, BOBCAT Series, Model 280 with a die-cast aluminum alloy crankcase with forged chromemoly crankshaft.

The travel of the fuel assembly, transfer car, and container is achieved by the use of a pusher arm. This arm is connected to a cable drive system. The cable drive system consists of underwater sheaves, stainless steel cable, and a winch located near the operating floor of the fuel building.

The fuel transfer car is equipped with an emergency pullout cable to withdraw the car from the transfer tube should a system breakdown occur.

During reactor operation, the transfer car is stored in the fuel storage area. A blind flange is bolted on the refueling canal end of the transfer tube to seal the reactor containment. The terminus of the tube outside the containment is closed by a gate valve.

The following safety features are provided in the fuel transfer system:

a. The transfer control system consists of two consoles; one on the containment side and the operator control station on the fuel building (FB) side. The containment side console has a programmable logic controller (PLC), relays, lights, and terminal strips for the interface of the components on the containment side. The fuel building side console has a PLC, relays, lights, and terminal strips for the interface of the components on the fuel building side. The containment and FB side consoles are connected by a network to allow status information and commands to be passed between the consoles. This along with the ability to stop the carriage from the refueling machine (RFM) console eliminates the need for an operator on the containment side transfer console. The system also allows auto initiation of the transfer machine from the refueling machine. The carriage

can be stopped from both transfer consoles as well as the RFM. This is accomplished through the power off pushbuttons and the carriage stop pushbuttons on both transfer consoles and the E-Stop pushbutton on the RFM. In the event of component failure, provisions have been made to bypass various system interlocks, if needed, to place the system in a safe condition.

b. Lifting arm (transfer car position)

Three conditions must exist to allow a lifting arm operation when the transfer car is at the respective travel end. These conditions are an end of travel proximity switch, an encoder position signal, and a minimum load value for the carriage at the end of travel. There is also a backup interlock which consists of a mechanical latch device on the lifting arm that is opened by the car moving into position.

c. Transfer car (valve open)

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. In the event of a limit switch failure on the gate valve, the interlock can be bypassed by the operator.

d. Transfer car (lifting arm)

The transfer car lifting arm is primarily designed to protect the equipment from overload and possible damage if an attempt is made to move the car when the fuel container is in the vertical position. This interlock is redundant and can withstand a single failure. The basic interlock is a position limit switch in the control circuit. The backup interlock is a mechanical latch device that is opened by the weight of the fuel container when it is in the horizontal position.

e. Lifting arm (refueling machine)

The refueling canal lifting arm is interlocked with the refueling machine. Whenever the transfer car is located in the refueling canal and the refueling machine is in the upender area, the lifting arm cannot be operated unless the refueling machine mast is at full up when loaded or within the mast when unloaded.

f. Lifting arm (spent fuel pool bridge crane)

The lifting arm is interlocked with the fuel handling machine. The lifting arm cannot be operated unless the spent fuel pool bridge crane is not over the lifting arm area.

ROD CLUSTER CONTROL CHANGING FIXTURE - The RCC changing fixture is used for periodic RCC element inspections and for the transfer of RCC elements from one fuel assembly to another. The major subassemblies which comprise the changing fixture are the frame and track structure, the carriage, the guide tube, the gripper, and the drive mechanism. The carriage is a movable container supported by the frame and track structure. The tracks provide a guide for the four flanged carriage wheels and allow horizontal movement of the carriage during the changing operation. The positioning stops on the carriage and frame locate each of the three carriage compartments directly below the guide tube. Two of these compartments are designed to hold individual fuel assemblies while the third is made to support a single RCC element.

The guide tube is situated above the carriage and is mounted on the refueling canal wall. The guide tube provides for the guidance and proper orientation of the gripper and RCC element as they are being raised and lowered. The gripper is a pneumatically actuated mechanism responsible for engaging the RCC element. It has two flexure fingers which can be inserted into the top of the RCC element when air pressure is applied to the gripper piston. Normally, the fingers are locked in the radially extended position. Mounted on the operating deck is the drive mechanism assembly which is composed of the manual carriage drive mechanism, the revolving stop operating handle, the pneumatic selector valve for actuating the gripped piston, and the electric hoist for elevation control of the gripper.

PORTABLE ROD CLUSTER CONTROL CHANGE TOOL - The portable rod cluster (RCC) change tool is used to remove an RCC from one fuel assembly and transfer it to another in the spent fuel pool. During use, this tool is suspended from the spent fuel pool bridge crane and is operated from the bridge walkway.

The tool is portable and functions in a manner similar to the RCC change fixture. The tool is lowered by the bridge hoist until it rests upon the nozzle of the desired fuel assembly. The gripper actuator is then lowered and latched onto the RCC spider which allows the entire RCC to be drawn up inside the guide tube of the tool. Once this operation is completed, the tool may be repositioned over another fuel assembly. This process is then reversed for reinsertion of the RCC.

The tool consists of three basic assemblies: the guide tube, the support tube, and the drive mechanism.

The guide tube is similar to that in the RCC change fixture. It is a square cross-sectioned tube at the bottom of the tool. Guide plates are provided over the entire length of the tube to prevent damaging the control rods and to properly align the gripper. The gripper actuator is also contained within the guide tube. It is a pneumatic device which operates the gripper from an air hose reaching through the support tube to the drive mechanism. Two limit switches provide upper and lower limits for the motion of the unit. The bottom of the guide tube is equipped with guide pins to ensure alignment of the tool with the fuel assembly.

Above the guide tube is the support tube which gives the proper length to the tool, provides support for the gripper actuator, and supplies protection for the lift cable. Also enclosed within the support tube are the air hose for the gripper and the electrical cable for connection of the limit switch. To prevent tangling of the hose and cable, the cable has been placed inside the coiled air hose with seals at each end to allow separation of the two.

The drive mechanism, at the top of the tool, consists of a winch powered by an ac electric motor, the operator's panel, and four limit switches. One of the limit switches provides overload protection in the event of an RCC hangup. The other three are geared limit switches, two providing upper and lower limits and the last providing control for the pneumatic system.

The tool weighs approximately 1045 pounds.

NEW FUEL ELEVATOR - The new fuel elevator consists of a box-shaped assembly with its top end open. The elevator is sized to house only one fuel assembly. It is located on the wall of the cask loading pool and is used primarily to lower a new fuel assembly to the pool bottom. When it is at the bottom of the pool, the fuel assembly is transported to either the fuel storage pool racks or to the container of the fuel transfer car by the use of the spent fuel pool bridge crane.

The new fuel elevator may also be used for fuel assembly reconstitution. During reconstitution, a fuel assembly that has previously been identified as needing repair may be moved from the spent fuel storage racks to the new fuel elevator where the repair work will be performed. The most common method for reconstitution is to remove the fuel assembly top nozzle, replace a defective fuel rod with a dummy (i.e. non-fuel bearing) rod, and reinstall the top nozzle.

SPENT FUEL ASSEMBLY HANDLING TOOL - The spent fuel assembly handling tool, also referred to as the long-handling tool, is used to manually handle the new and spent fuel in the fuel storage pool. An operator on the spent fuel pool bridge crane guides and operates the tool. The tool is designed to maintain its integrity during an SSE.

The tool employs four cam-actuated latching fingers which grip the underside of the fuel assembly top nozzle. When the fingers are latched, a lock pin is inserted into the operating handle to prevent the fingers from being accidentally unlatched during fuel handling operations.

The tool weighs approximately 356 pounds and is preoperationally tested at 125 percent the weight of one fuel assembly with control assembly inserted (1,600 pounds).

NEW FUEL ASSEMBLY HANDLING TOOL - The new fuel assembly handling tool is a short-handled device located on the cask handling crane monorail. It is used to handle new fuel on the operating deck of the fuel building, to remove the new fuel from the

shipping container, and to facilitate inspection and storage of the new fuel and loading of fuel into the new fuel storage racks and the new fuel elevator.

The new fuel assembly handling fixture employs four cam-actuated latching fingers which grip the underside of the fuel assembly top nozzle. When the fingers are latched, the safety mechanism on the side of the tool is turned in to prevent accidental unlatching of the fingers.

The tool weighs approximately 100 pounds and is preoperationally tested at 125 percent the weight of one fuel assembly (1,600 pounds).

REACTOR CAVITY SEAL RING - A watertight seal ring is provided for installation between the reactor vessel flange and the floor of the refueling pool. A seal is provided between the reactor vessel flange and the seal ring to form this watertight seal. The seal is removed during reactor operation to allow postaccident reactor cavity venting and normal primary shield wall cooling. Since the seal is removed under normal operation, it is not a credible missile. The normally open lines connecting the bottom of the refueling pool with the containment normal sump are sealed with blind flanges during refueling only.

9.1.4.2.3 System Operation

The fuel handling equipment is designed to handle the spent fuel assembly under water from the time it leaves the reactor vessel until it is placed in a container for storage at the onsite ISFSI or shipment from the site. Underwater transfer of spent fuel assemblies provides an effective, economic, and transparent radiation shield, as well as a reliable cooling medium for the removal of decay heat.

Fuel is moved between the reactor vessel and the refueling canal by the refueling machine. A RCC changing fixture is located in the refueling canal for transferring control elements from one fuel assembly to another. The fuel transfer system is used to move fuel assemblies between the containment building and the fuel storage building. 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 fuel transfer tube.

The fuel transfer tube is fitted with a flange on the refueling pool end and a gate valve on the fuel transfer canal end.

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.

During nonrefueling operations, a blind flange seals the containment side of the transfer tube in order to ensure the leaktight integrity of the containment. Two quad ring seals are located around the periphery of the blind flange with leak-check provisions between them in order to perform a Type B test per 10 CFR 50, Appendix J.

In the fuel storage building, fuel assemblies are moved about by the fuel handling machine. When lifting fuel assemblies, the hoist uses a long-handled tool to assure that sufficient radiation shielding is maintained. A shorter tool is used to handle new fuel assemblies initially, but the new fuel elevator must be used to lower the assembly to a depth at which the fuel handling machine, using the long-handled tool, can place the new fuel assemblies into or out of the fuel storage racks.

Decay heat, generated by the spent fuel assemblies in the fuel storage area, is removed by the spent fuel pool cooling and cleanup system. After a sufficient decay period, the spent fuel assemblies may be removed from the fuel racks and loaded into Multi-Purpose Canisters (MPCs) for storage at the onsite ISFSI or shipping for removal from the site.

9.1.4.2.3.1 Fuel Handling System Operations

NEW FUEL RECEIVING AND STORAGE - New fuel assemblies are delivered to the site by truck or rail in approved containers. A new fuel assembly is unpacked in the shipping/ receiving area and then, with the use of the monorail hoist on the cask handling crane, is moved to the new fuel inspection area (a strongback is used initially to upend and prevent the bowing of the new fuel assembly). While the new fuel assembly is in this area, any shipping spacers present are removed, the cleanliness is verified, and the assembly is visually inspected for any damage.

Following inspection, the new fuel is transferred by means of the monorail hoist on the cask handling crane to the new fuel storage racks in the new fuel storage vault or to the spent fuel storage racks via the new fuel elevator in accordance with plant procedures.

REFUELING PROCEDURE - The refueling operation follows a detailed procedure which provides a safe, efficient, refueling operation. The following significant points are assured by the refueling procedures:

a. The refueling water and the reactor coolant are maintained at a concentration of at least 2000 ppm boron. This concentration, together with the negative reactivity of the control rods, is sufficient to keep the core approximately 5-percent $\Delta k/k$ subcritical during the refueling operations. It is also sufficient to maintain the core subcritical in the unlikely event that all of the RCC assemblies were removed from the core.

   While the refueling pool is flooded, items removed from the pool are sprayed down using unborated water. This is performed to facilitate the decontamination of those items. Administrative controls will prevent diluting the pool below acceptable boron concentration limits.

b. The water level in the refueling pool is high enough to keep the radiation levels within acceptable limits when the fuel assemblies are being removed from the core.

The refueling operation is divided into five major phases:

Phase I - Preparation

Phase II - Reactor disassembly

Phase III - Fuel handling

Phase IV - Reactor reassembly

Phase V - Preoperational checks and startup

Phase I - Preparation

The reactor is shut down, borated, and cooled to cold shutdown conditions (≤140°F) with a final $k_{eff} \leq 0.95$ and all rods inserted.

When the containment radioactive iodine concentration reaches acceptable levels to meet offsite dose limits, the containment purge system purges the containment of noble gases.

Following a radiation survey, the containment is cleared for refueling personnel entry. Degassing of the reactor coolant system (refer to Section 11.3.2.2) may be performed either before or after the pressurizer heaters are secured and additional pressurizer spray flow is used to collapse the steam bubble. In addition to degassing, forced oxidation of the reactor coolant may also be performed in order to promote solubilization and removal of corrosion products that may have deposited within the reactor core during the previous operating cycle. This practice prevents or minimizes the likelihood of a subsequent release and re-deposition of corrosion products in the reactor coolant system loops during refueling operations, thereby improving the clarity of the refueling pool and reducing dose rates. Forced oxidation is accomplished by adding a pre-determined amount of hydrogen peroxide to the reactor coolant in accordance with chemistry procedures.

If the reactor coolant system degassing and/or forced oxidation is to be initiated prior to collapsing the pressurizer steam bubble, auxiliary spray is established, and N2 is added to the top of the pressurizer to dilute a potentially explosive concentration of H2 that may come out of solution during cooldown. After the H2 is diluted to sufficient levels, the mixed gas solution is vented. The use of a vacuum eductor may be used to aid in venting off the mixed gas solution. The RHR system is in operation, and the safety injection pumps and accumulator isolation valves are either locked out or closed and deenergized. The gaseous radwaste system is in operation, and sufficient holdup tank capacity is available to receive reactor coolant from impending draindown. Venting the pressurizer may be deferred until pressurizer pressure and water level are both reduced if the following conditions are met: hydrogen concentration of the pressurizer liquid and vapor space has been reduced to below 4% by chemical degassing, the pressurizer

vapor space is off-gassed to the pressurizer relief tank, high-pressure nitrogen is supplied to the pressurizer, and oxygen controls are sufficient to maintain oxygen concentration below 3%.

The pressurizer spray valves are in the manual control mode and are fully open with the pressurizer heater circuit breakers open and tagged. The setpoint of the pressurizer relief tank regulator is reduced to 0.5 psig. The reactor vessel flange leakoff manual valves are closed. Next, the control room level indications for reduced RCS inventory are placed in service. Continuous control room level indication is provided from the pressurizer to below the lowest RCS level necessary for operation of the RHR system. Redundant control room level indications are provided when RCS level is less than three feet below the reactor vessel flange. The primary RCS reduced inventory indication is provided by BBLT0053A, BBLT0053B, and BBLT0053BB. A level indicating hose can be connected to its connection off the loop No. 1 crossover leg and extended above the top of the pressurizer if needed as a backup. Either the chemical and volume control system or the reactor coolant drain tank pumps are aligned to drain the reactor coolant system (RCS) and discharge to the recycle holdup tanks. The drainage rate of the RCS is controlled so as not to exceed the capacity of the CVCS or the reactor coolant drain tank pumps. As draindown is initiated, the CVCS or RCDT pumps are throttled to control the rate of draindown. The draindown continues unabated until the bottom of the pressurizer is reached, at which point the rate is decreased. A nitrogen supply is attached to the vessel head via the vent connection. This step will raise the indicated level in the pressurizer. The draining is reestablished until the level is at approximately the top of the reactor vessel head. At this point, the draining is interrupted and the nitrogen supply is removed after the vessel head vent is closed. Then, the reactor vessel head vent is slowly opened. If chemical degassing has been performed via the addition of hydrogen peroxide, nitrogen injection to the vessel head may not be necessary. The draindown is continued until the level is approximately 4 inches below the vessel flange. At this point, the draining is terminated and all loop drain valves are isolated. The fuel transfer equipment, refueling machine, and polar crane are checked for proper operation prior to use. After the water level has been reduced, the incore thimbles are withdrawn into the removable support frame, and the low pressure seals are installed. This is performed any time before step i of Reactor Disassembly.

Phase II - Reactor Disassembly

Prior to vessel head disassembly, several items in the vicinity of the vessel must be disconnected and removed. The following steps are not necessarily performed in the order shown here.

a. Deleted.

b. Deleted.

c. Deleted.

d. The incore instrumentation thimble guides are removed from the core. All cables connected to the vessel head (rod position indication and CRDM power cables, upper instrumentation thermocouple leads, and upper head loose parts monitoring leads and CRDM cooling system related cables/ leads) are disconnected at the junction boxes located near the refueling pool wall.

e. Deleted.

f. The insulation is removed from the vessel head.

g. The refueling pool is then prepared for flooding by installing the reactor cavity seal; the stud tensioner hoists are installed if necessary and connected by means of temporary power cords; the reactor vessel (RV) head nuts are loosened using the stud tensioners; the stud tensioner hoist power cords are disconnected and stored; the RV head nuts and studs are removed; studs which cannot be removed are protected from exposure to borated pool water; the guide studs are installed and the remainder of the stud holes are plugged; the drain screens over the refueling pool drain are removed and the blind flanges are installed; the underwater lights, tools, and fuel transfer system are checked; and the blind flange from the fuel transfer tube is removed.

h. With the refueling pool prepared for flooding, the vessel head is unseated and lifted to a height sufficient to ensure the RCCA's have disconnected. The lift is then continued till the head is clear of the guide studs and less than 2 feet above the 2047’-6” elevation, the vessel head is then moved south over the refueling pool. Then the vessel head is lifted, along with the Integrated Head Assembly (IHA), and placed on its storage pedestal.

i. Water from the refueling water storage tank is pumped into the RCS by the residual heat removal pumps, causing the water to overflow into the refueling pool.

j. The control rod drive shafts are disconnected from the RCC assemblies and, with the upper internals, are removed from the vessel and stored in the refueling pool or stored in the racks designed for this purpose.

k. The fuel assemblies and RCC assemblies are now free from obstructions, and the system is ready for the fuel handling phase.

Phase III - Fuel Handling

Prior to initiation of the refueling sequence, the refueling pool water level is raised to the same level as the fuel storage pool and either the gate valve is opened or the transfer slot gate is removed. In this condition, there is communication between the fuel building

pools and the refueling pool; therefore, level monitoring, including a low level alarm, is provided by the fuel pool cooling and cleanup system. The fuel storage pool water level is required to be at least 23 feet above the top of the storage racks when moving irradiated fuel in the fuel building. The refueling pool water level is required to be at least 23 feet above the reactor vessel flange when moving irradiated fuel in containment and when moving new fuel or the dummy fuel assembly over the reactor vessel with irradiated fuel in the reactor vessel. This is in accordance with the assumptions for the fuel handling accident.

While the refueling pool is flooded, items removed from the pool are sprayed down using unborated water. This is performed to facilitate the decontamination of those items. Administrative controls will prevent diluting the pool below acceptable boron concentration limits.

The refueling sequence is started with the refueling machine. Spent fuel assemblies are removed from the core in the sequence prepared by plant personnel before each refueling. The positions of partially spent fuel assemblies are changed, and new fuel assemblies are transferred to the core.

A typical fuel handling sequence is:

a. The refueling machine is positioned over a fuel assembly in the most depleted region of the core.

b. The fuel assembly is lifted by the refueling machine to a predetermined height sufficient to clear the reactor vessel and still leave sufficient water covering to eliminate any radiation hazard to the operating personnel.

c. If the removed assembly contains an RCC unit or a source assembly, the assembly is placed in the RCC changing fixture by the refueling machine or it may be transferred to the fuel building for changeout using the portable RCC change tool. The RCC assembly is removed from the spent fuel assembly and deposited in a partially spent or new fuel assembly previously placed in the changing fixture. If a removed assembly contains a burnable poison rod assembly or assemblies other than an RCC unit, the assembly remains intact until the fuel assembly reaches the spent fuel pool where it may be removed by a handling tool and placed in the rack insert.

d. The fuel transfer car is moved into the refueling pool from the fuel transfer canal.

e. The fuel carriage is pivoted to the vertical position by the upender.

f. The spent fuel assembly is moved by the refueling machine from the changing fixture to the fuel transfer car.

g. The refueling machine is moved to line up the spent fuel assembly with the fuel assembly container and load the spent fuel assembly into the assembly container of the carriage.

h. The carriage is pivoted to the horizontal position by the upender.

i. The carriage is moved through the fuel transfer tube to the fuel transfer canal by the transfer car.

j. The carriage is pivoted to the vertical position. The spent fuel assembly is unloaded by the spent fuel handling tool attached to the spent fuel bridge crane.

k. The spent fuel assembly is transferred through the fuel storage pool transfer gate, as necessary, and is placed in a designated location in the fuel storage pool racks.

l. The new fuel assembly is brought from dry storage by the monorail hoist on the cask handling crane, placed in the new fuel elevator, and lowered into the cask loading pool. The fuel assembly is then transferred through the cask loading pool gate, the fuel storage pool, and the transfer canal gate to the transfer canal where it is loaded into the fuel assembly carriage by the spent fuel pool bridge crane and spent fuel handling tool. Prior to beginning the refueling sequence, the operator may deposit all required new fuel assemblies in the fuel storage pool to reduce the number of steps necessary to complete the fuel handling sequence.

m. The carriage is pivoted to the horizontal position, and the transfer car is moved back into the refueling pool.

n. Partially spent fuel assemblies are relocated in the reactor core, and new fuel assemblies are added to the core.

o. Any new fuel assembly or transferred fuel assembly that is placed in a control position is first placed in the RCC changing fixture to receive an RCC unit from a spent fuel assembly or a partially spent fuel assembly which is being removed from a control position unless an RCC was received in the fuel storage pool.

p. This procedure is continued until refueling is completed.

The reactor is now ready for the reassembly phase.

Phase IV - Reactor Reassembly

The reactor reassembly, following refueling, is essentially achieved by reversing the operations given in Phase II - Reactor Disassembly. The following steps are not necessarily performed in the order shown here.

The general sequence is:

a. Close the gate valve on the fuel building side of the fuel transfer tube or place the gate on the west transfer slot of the fuel storage pool.

b. The reactor vessel upper internals are replaced in the vessel by the polar crane. The internal lifting rig is removed to storage.

c. The CRD shafts are relatched to the RCC elements.

d. Initiate draining of the refueling pool, utilizing the RHR pumps and their connections in the hot legs of the reactor coolant loops. During this draining evolution, the refueling pool walls are sprayed down with unborated water to facilitate decontamination activities. Administrative controls will prevent diluting the pool below acceptable boron concentration limits.

e. The water level is drained to approximately one foot above the reactor cavity seal/shield ring. The pool is then drained via the reactor coolant drain tank (RCDT) pumps or other available means (excluding the RHR system) until the level is below the cavity seal/shield ring. This will direct the potentially diluted layer of water at the top of the pool away from the reactor vessel and core.

f. After the level has been lowered to below the cavity seal/shield ring, further draining of the area enclosed by the inside diameter of the ring will be performed via the RHR connection to CVCS letdown.

g. Complete draining the remainder of the refueling pool as needed via the RCDT pumps or other available means. After draining is completed, the reactor vessel flange surface is cleaned. The above administrative controls (items d-g) will minimize the amount of unborated water which could enter the reactor vessel from washdown procedures.

h. The reactor vessel head is lifted using the polar crane and positioned less than 2 feet above the 2047’-6” elevation. The head is then moved over the reactor vessel, the guide studs are engaged and the head is set on the vessel flange.

i. Install vessel head, remove stud hole plugs, insert studs, remove head guide studs, connect power cords to the stud tensioner hoists, tension head studs, disconnect and remove stud tensioner hoists and store the power cords.

j. Decontaminate refueling pool walls.

k. Remove the cavity seal.

l. The blind flange is attached to the refueling canal side of the fuel transfer tube. If the gate valve on the fuel transfer tube is open, it is now closed.

m. Install vessel head insulation.

n. Install the RPI cables, upper instrumentation thermocouple leads, CRDM power cables, and upper head loose parts monitoring leads and CRDM cooling system related cables/leads and make all cable connections.

o. The incore instrumentation thimble guides are reinserted into the core and sealed at the seal table.

p. Deleted.

q. Deleted.

Phase V - Preoperational Checks and Startup

After the refueling pool has been drained, the reactor assembled, and the fuel transfer tube has been isolated, cleanup of the fuel handling areas within the containment building is performed in accordance with the established station housekeeping procedures.

The blind flanges covering the refueling pool drain holes are removed and stored in designated locations, and the refueling pool drain screens are replaced. Any maintenance which is required on fuel handling equipment inside the containment is done during this general cleanup phase of refueling.

DRY CASK STORAGE - The HI-STORM UMAX FSAR contains detailed descriptions of the HI-STORM UMAX System, including the HI-TRAC VW transfer cask, the Multi-Purpose Canister (MPC), and the Vertical Ventilated Module (VVM). The design bases of the HI-STORM UMAX System are described in the UMAX Certificate of Compliance (CoC) and the UMAX FSAR (Docket No. 72-1040). Additional details regarding the use and operation of the HI-STORM UMAX System can be found in the 72.212 Evaluation Report.

After a decay period as defined by the HI-STORM UMAX CoC, the spent fuel may be removed from the fuel storage pool/racks and transferred to the spent fuel storage canister. During loading operations, the HI-TRAC VW transfer cask containing an empty MPC, is lowered into the cask loading pit and set on the upper level of the VECASP. The single failure proof Cask Handling Crane (CHC) and lift yoke are used to perform the movement of this heavy load. The lift yoke extension is then installed with the lift yoke on

the CHC, and the HI-TRAC VW transfer cask with MPC is lowered to the bottom pedestal of the VECASP for loading of spent fuel. Spent fuel is then loaded into the empty MPC using the Spent Fuel Pool Bridge Crane.

When fuel loading hs been completed, the HI-TRAC VW transfer cask and loaded MPC are raised to the upper level of the VECASP with the CHC, lift yoke and lift yoke extension. The MPC lid is placed on the loaded canister using the CHC, lift yoke, and lift yoke extension as required. The transfer cask is then moved to the cask washdown pit for welding of the MPC lid and forced helium dehydration.

Once in the cask washdown pit, the MPC is prepared for closure. The MPC lid is welded to the shell and pressure tested to ensure the weld is leak tight. The MPC is blown-down and dried in preparation for forced helium dehydration. After forced helium dehydration has been completed, the MPC is backfilled with helium to promote heat transfer and prevent cladding degradation. The vent and drain cover port plates are then welded in place and helium leak tested, before the closure ring is welded in place.

The loaded and sealed MPC and HI-TRAC VW transfer cask are then removed from the cask washdown pit and loaded onto the HI-PORT transporter using the CHC. The HI-PORT transporter removes the transfer cask and loaded MPC from the Fuel Building, along the heavy haul path and to the transfer pad. The HI-TRAC VW transfer cask and MPC are then removed from the HI-PORT using the Vertical Cask Transporter (VCT), which transports the transfer cask and MPC to the designated storage location in the ISFSI pad.

Once the Mating Device and Mating Device Adapter have been installed on the selected Cavity Enclosure Container (CEC), the MPC is ready to be lowered into the VVM. After removing the bottom lid of the HI-TRAC VW transfer cask, the MPC is slowly lowered down through the HI-TRAC VW transfer cask into the VVM. The Mating Device and Mating Device Adapater are then removed, and the closure lid is installed on the VVM.

The heat transfer capabilities of the VVM closure lid are monitored by inspection of the inlet and outlet vent screens on a daily basis.

The Cask Handling Crane (CHC) is single-failure proof as defined by NUREG-0554 (1979). Positive mechanical end stops are installed on the runway for limiting the bridge travel and on the bridge girders for limiting the trolley travel. Travel limit switches are provided for the bridge and trolley to prevent over-travel. Mechanical end stops prevent the CHC from accessing areas over the spent fuel pool storage areas while carrying a load.

9.1.4.3 Safety Evaluation

Safety evaluations are numbered to correspond to the safety design bases in Section 9.1.4.1.1.

SAFETY EVALUATION ONE - The safety-related portions of the FHS are located in the reactor and fuel buildings. These buildings are designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other appropriate natural phenomena. Sections 3.3, 3.4, 3.5, 3.7(B), and 3.8 provide the bases for the adequacy of the structural design of these buildings.

SAFETY EVALUATION TWO - The safety-related portions of the FHS are designed to remain intact after an SSE. Section 3.7(B) provides the design loading conditions that were considered. Sections 3.5, 3.6, and 9.5.1 provide the required hazards analysis.

SAFETY EVALUATION THREE - The FHS is initially tested with the program given in Chapter 14.0. Periodic inservice functional testing is done in accordance with Section 9.1.4.4. The fuel transfer tube is inspected in accordance with the technical requirements of ASME Section XI.

SAFETY EVALUATION FOUR - Section 3.2 delineates the seismic category applicable to the safety-related portions of this system.

SAFETY EVALUATION FIVE - Sections 6.2.4 and 6.2.6 provide the safety evaluation for the system containment isolation arrangement and testability.

SAFETY EVALUATION SIX - In the event of a fuel handling accident in the fuel building, the radiological consequences analyzed in Chapter 15.0 demonstrate that the 10 CFR Part 100 guideline values are not exceeded. The circumstances resulting in a handling accident are limited to the following conditions.

a. Fuel drop from a lifting device

b. Improper operation of the transfer equipment and cranes

c. DELETED

d. Drop of the RV head

The fuel handling equipment is designed to prevent a fuel assembly drop by providing special gripping devices which are locked in a manner which will not allow the release of the fuel assembly during transfer. The special features are described in Section 9.1.4.2.2.

Improper operation of the fuel transfer system is prevented by the location of special limit switches and interlocks which will not allow the movement of fuel assemblies unless they are properly oriented, thus avoiding a fuel handling accident. Further description of these devices is given in Section 9.1.4.2.2.

Limit switches and interlocks located on the fuel handling cranes in conjunction with administrative controls prevent any improper operations which may result in a fuel

handling accident. The limiting devices on the refueling machine and spent fuel pool bridge crane do not allow fuel to be moved unless it is in the proper orientation and handled correctly in the gripping tool of the crane.

Concerning the handling of loads over fuel in the fuel storage pool, administrative controls will be employed to prevent the handling of loads that have a greater potential energy than those which have been analyzed.

As discussed in References 5 and 6, the fuel storage pool racks will absorb the impact of a dropped fuel storage pool transfer gate without damage to fuel assemblies. When moving a fuel storage pool transfer gate, administrative controls limit lift height and redundant trolleys and supports are used. Therefore, it is acceptable to lift the gates over fuel assemblies stored in the spent fuel racks with the exception of fuel assemblies which contain Rod Cluster Control Assemblies (RCCAs).

RCCAs in fuel assemblies extend above the top of the spent fuel racks but below the lead-in guides installed on the racks. Since References 5 and 6 do not take any credit for the lead-in guides, it is assumed that the impact of a dropped gate would be absorbed by the RCCA rather than by the fuel storage pool racks, which could potentially damage the fuel assembly containing the RCCA.

Therefore, administrative controls prevent movement of the gates over fuel assemblies which contain RCCAs.

As a precautionary measure, administrative controls also minimize (as much as practical) the time and distance the gates are moved over fuel assemblies (e.g., the gates are moved the shortest possible distance between their storage locations and the transfer slot/seal replacement locations). The fuel storage pool transfer gates are only moved across the fuel storage pool to either the transfer canal or cask loading pool to change the gate seals, which are replaced approximately every 5-6 years, for refueling activities, or for fuel handling system maintenance.

The transfer gate between the cask loading pool and the spent fuel pool will not be installed in the transfer slot if fuel is stored in the racks in the cask loading pool.

The spent fuel cask handling equipment has been upgraded to single-failure-proof status to provide the maximum practical defense-in-depth in accordance with NUREG-0612 and to allow the use of the spent fuel cask handling and lifting devices to handle heavy loads in the vicinity of spent fuel without the need for load drop analysis.

During reactor vessel head assembly removal or reassembly, it is postulated that the polar crane fails. If this unlikely event should occur various consequences would prevail depending upon the position of the vessel head assembly in relation to the reactor vessel at the time of the polar crane cable failure. WCAP-9198 identified six different accident cases. Out of these six different accident cases the worst case scenario is a head drop directly above the flange where the head engages the guide studs and does not bind.

The plant analysis of this scenario concludes that the limiting case for a head drop accident is failure of the reactor nozzles. The output of this analysis is a graph of the maximum head lift height for various head weights, seen in Figure 9.1-25. The maximum height is the height at which the head can be dropped and will not cause failure of the reactor vessel nozzles. Figure 9.1-25 also has a reference line of 28' above the reactor flange, which is approximately 2' above the containment floor around the refuel pool.

The analysis shows that the total deformation never exceeds 2.2 inches for the head weights evaluated at their respective maximum head lift heights in Figure 9.1-25. 2.2 inches are the acceptance criteria for total deflection in the reactor vessel supports in the original calculation. Therefore, the total deflection in the reactor vessel supports is bounded by the deflection in the reactor vessel nozzles.

The maximum allowed head lift height from Table 9.1-9 and Figure 9.1-25 is 44 feet. In keeping with ALARA practices, the head lift will be restricted to a maximum height of 28 feet above the reactor vessel flange. Lifting the head to 28 feet above the reactor vessel flange will minimize the dose received by personnel from the inside of the reactor head.

As part of installation of an Integrated Head Assembly (IHA) to replace the CRDM Service Structure, a calculation, which incoporates a more refined finite element analysis as discussed in Reference 10, has been prepared to document the results of a postulated 31-foot head drop of the new Replacement Reactor Vessel Closure Head (RRVCH) and IHA onto the reactor vessel flange.

Due to changes in lift height, there is the possibility that the head will impact the floor at a higher velocity than previously analyzed. Floor failures were generally found to have no effect on the cold shutdown and decay heat removal capabilities when all intervening floors were assumed to fail. This is due to the design bases layout of the plant, which separates the redundant trains on opposite sides of the reactor building. Train A components, piping, electrical supplies, and supporting systems are located at all elevations to the north of the east/west centerline and Train B items are located to the south of the center line.

Loads placed on the fuel assemblies by the postulated reactor vessel head drop are based on the buckling of the control rod drive shafts. This load has been evaluated and damage would not be expected to the fuel assembly structure and the fuel cladding integrity would be maintained. This evaluation is applicable to Westinghouse fuel (References 7, 8, 9).

9.1.4.4 Tests and Inspections

The fuel handling equipment is used extensively for short periods of time spaced by months of idle time. Equipment operability is capable of being verified prior to fuel handling. This checkout procedure includes the handling and shuffling of a dummy fuel assembly from one spare location to another within the fuel storage pool, operation of the new fuel elevator, and transfer of the dummy fuel assembly through the transfer

mechanism. The refueling machine is similarly operated, and the dummy fuel assembly is lifted out of the transfer mechanism and returned.

Before or during preoperational testing, all lifting devices and components such as bridges, cranes, etc., are tested at 125 percent of their rated loads.

Prior to use, all components and interfacing portions of the components are checked to ensure proper matchup and to make sure they are free of foreign or loose parts.

Normal maintenance of all fuel handling equipment is performed in accordance with the manufacturer's recommendations.

9.1.4.5 Instrumentation Applications

Mechanical or fail-safe electrical interlocks are provided, when required, to ensure the proper and safe operation of the fuel handling equipment which could endanger the operator or damage the fuel assemblies. All other interlocks are intended to provide equipment protection and may be implemented either by mechanical or by electrical interlocks, not necessarily fail safe.

The cranes and fuel transfer system are provided with limit switches to guard against improper travel and operations and to ensure correct and safe handling of the fuel assemblies. More specific details and descriptions of the limit switch applications are given in Section 9.1.4.2.2 for each major component where they may apply.

9.1.4.6 Administrative Controls for Fuel Handling Activities

Administrative controls are implemented so that while a spent fuel assembly is in the new fuel elevator, the gate between the spent fuel pool and the cask loading pool is not installed. In addition, administrative controls prohibit the handling of a spent fuel cask over the cask loading pool while a spent fuel assembly is in the new fuel elevator. These administrative controls ensure that while a spent fuel assembly is located in the new fuel elevator, the water level in the cask loading pool remains within the bounds of the Fuel Handling Accident Analysis and the probability of dropping a cask on the new fuel elevator is not a possibility.

9.1.5 Control of heavy loads

9.1.5.1 Introduction/Licensing Background

NRC Generic Letter (GL) 81-07 was issued on December 22, 1980 along with enclosure NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants". The term "heavy load" is defined in NUREG-0612 as a load whose weight is greater than the combined weight of a single spent fuel assembly and its handling tool. For SNUPPS plants, including Callaway, this weight is approximately 2000 pounds; therefore, a "heavy load" is defined at Callaway as a load >2000 pounds.

GL 81-07 provided guidance for Phase I (6-month) and Phase II (9-month) responses. The Callaway Plant Phase I response was submitted to the NRC under the cover of SLNRC 81-48 dated June 22, 1981. The Callaway Plant Phase II response was submitted to the NRC under the cover of SLNRC 82-33 dated August 4, 1983. The Phase II response was re-submitted with additional information in letters SLNRC 84-08, SLNRC 84-56, and SLNRC 85-09, "SNUPPS Report on the Control of Heavy Loads."

NRC Bulletin 96-02, "Movement of Heavy Loads over Spent Fuel, over Fuel in the Reactor Core, or over Safety-Related Equipment," was issued April 11, 1996. The Callaway Plant response was submitted to the NRC under the cover of ULNRC-3366.

On July 27, 1999 the NRC docketed ULNRC-4056, "Amended Response to Generic Letter 81-07, 'Control of Heavy Loads'." This amended response resolved a discrepancy between earlier submittals of the "SNUPPS Report on the Control of Heavy Loads" and Callaway Plant Technical Specifications regarding Residual Heat Removal (RHR) system operability and protection during Cold Shutdown (Mode 5) and Refueling (Mode 6).

NRC Regulatory Issue Summary (RIS) 2005-25, "Clarification of NRC Guidelines for Control of Heavy Loads," which provided insights based on nuclear industry crane operating experience to clarify and re-emphasize the NUREG-0612 guidance was issued October 31, 2005. Supplement 1 to NRC RIS 2005-25, issued May 29, 2007, provided additional guidance related to rigging used with single-failure-proof handling systems, and calculational methodologies for heavy load drop analyses.

While no licensee response was required for NRC RIS 2005-25 or its Supplement 1, the guidance provided in these documents is reflected in the procedurally-controlled Callaway Plant Lifting and Rigging Program.

In July 2008, NEI 08-05, "Industry Initiative on Control of Heavy Loads," Revision 0 was issued to provide guidelines specifying actions for each plant to take to ensure that heavy load lifts continue to be conducted safely and that plant licensing bases accurately reflect plant practices.

NRC RIS 2008-28, "Endorsement of Nuclear Energy Institute Guidance for Reactor Vessel Head Heavy Load Lifts," issued December 1, 2008, states licensees may use the guidelines developed by the Nuclear Energy Institute (NEI) and contained in NEI 08-05, Revision 0 to voluntarily establish a revised licensing basis for handling of reactor vessel heads and other heavy loads that is consistent with the provisions of Title 10 of the Code of Federal Regulations (10 CFR) Section 50.59, "Changes, Tests and Experiments."

In 2014, the original reactor vessel head was replaced with a new Replacement Reactor Vessel Closure Head (RRVCH) and Integrated Head Assembly (IHA). An analysis was performed in accordance with the endorsed guidance of NEI 08-05 to establish a new licensing basis for heavy loads control during handling of the RRVCH /IHA.

9.1.5.2 Safety Basis

Callaway was one of five plant sites selected by the NRC to have the GL 81-07 Phase II response fully reviewed under a pilot program. The NRC reviewed the Callaway Phase I and II responses and found them to be acceptable, as documented in Appendices G and H of supplement 3 to NUREG-0830, "Safety Evaluation Report Related to the Operation of Callaway Plant Unit No. 1." Subsequently, Generic Letter (GL) 85-11 informed licensees that based upon the improvements in heavy loads handling after the implementation of NUREG-0612 (Phase 1), further action was not required to reduce the risks associated with the handling of heavy loads. The NRC determined that a detailed Phase II review of heavy loads was not necessary for any additional plants.

Except for the cask handling crane, Callaway Plant cranes are not claimed to be single failure proof as defined in NUREG-0554, "Single-Failure-Proof Cranes for Nuclear Power Plants." The reactor vessel head drop analysis applicable to Westinghouse fuel, and with the lift medium being air, is discussed in Section 4.2.b, Safety Evaluation 6.d of Section 9.1.4.3, Figure 9.1-25, and Table 9.1-9.

The cask handling crane has been upgraded to be single-failure proof as defined in NUREG-0554. Refer to Section 9.1.4.2.2, Safety Evaluation 6.c of Section 9.1.4.3 and Section 15.0.1.3.

9.1.5.3 Scope of Heavy Load Handling Systems

A list of overhead cranes that are used to handle heavy loads in the area of the reactor vessel or spent fuel in the spent fuel pool is contained in Table 9.1-7, "Fuel Handling Crane Data," and in the Callaway Plant Lifting and Rigging Program. A list of permanent miscellaneous hoists used in areas containing safe shutdown equipment is also maintained in the Callaway Plant Lifting and Rigging Program.

9.1.5.4 Control of Heavy Loads Program

The control of heavy loads is incorporated in the procedurally controlled Callaway Plant Lifting and Rigging Program. The program consists of:

1. Commitments to the SNUPPS Report on the Control of Heavy Loads.
2. Load drop analysis for reactor pressure vessel head lifts.
3. Administrative controls for heavy loads lifts over or in the vicinity of safe shutdown equipment or irradiated fuel, including:
    a. Established load paths in the Reactor and Fuel Buildings,
    b. Load drop analysis utilizing the standardized methodology described in NRC RIS 2005-25 Supplement 1,

c. A 10 CFR 50.59 screening and review of lift plans, if applicable.

4. Administrative controls for the design and maintenance of special and engineered lifting devices that may be used for heavy load lifts over or in the direct vicinity of safe shutdown equipment or irradiated fuel.

5. Administrative controls on the design and selection of non special or engineered lifting devices that may be used for heavy loads lifts over or in the direct vicinity of safe shutdown equipment or irradited fuel.

6. Demonstration requirements for interlocks that prevent heavy loads from being carried over irradiated fuel.

7. Administrative controls for operation of a single-failure proof crane used for spent fuel cask handling in the Fuel Building.

9.1.5.4.1 Licensee Commitments in Response to NUREG-0612, Phase I Elements

Element 1: Definition of safe load paths

Safe load paths delineated on maps contained in the Callaway Plant Lifting and Rigging Program have been developed for the Reactor Building and Fuel Building areas. Deviation from these heavy load paths requires an engineering evaluation and Onsite Review Committee approval prior to the lift. Cranes that can travel over the spent fuel pool have interlocks to prevent carrying heavy loads over the fuel. These interlock restrictions are described in Section 16.9.3.

Load paths for other areas of the plant that contain safe shutdown equipment may be developed on a case-by-case basis, because the train separation design of the plant minimizes the impact of a single load drop on the capability to establish and maintain safe shutdown of the plant. Guidelines are provided in the Callaway Plant Lifting and Rigging Program to aid the riggers and operators in determining the detail required in the job analysis for these lifts.

Element 2: Development of load handling procedures

Procedures are in place that govern the lifting of reactor vessel components and spent fuel. Procedural guidance for other lifts is contained in the Callaway Plant Lifting and Rigging Program

Element 3: Qualifications, training, and specified conduct of crane operators

Qualification, training, and conduct of crane operators are contained in the Callaway Plant Lifting and Rigging Program. The training is governed by Callaway's accredited technical training program and meets all the requirements of ANSI B30.2 - 1976, "Overhead and Gantry Cranes."

Element 4: Special lifting devices should satisfy the guidelines of American National Standards Institute (ANSI) N14.6-1978

Load cell, linkage, and lifting rigs for the reactor vessel head/vessel internals and the lifting device for spent fuel casks are the only recognized special lifting devices at the Callaway Plant. The guidelines in the Callaway Plant Lifting and Rigging Program for the design and maintenance of the special lifting devices specifically refers to NUREG- 0612 and thus ANSI N14.6-1978, "Standard for Special Lifting Devices for Shipping Containers Weighing 10,000 pounds (4500 Kg) or More for Nuclear Materials."

Element 5: Lifting devices that are not specifically designed should be installed and used in accordance with the guidelines of ANSI B30.9

Guidance for the design and use of non-specially designed lifting devices is provided in the Callaway Plant Lifting and Rigging Program with the guidelines meeting all the requirements of ANSI B30.9-1971, "Slings."

Element 6: Periodic inspection and testing of cranes

Callaway cranes are contained in a procedure controlled Preventative Maintenance Program. Guidance from ANSI B30.2-1976 is used in establishing the frequency of the inspection and maintenance activities. Inspections and maintenance on the containment polar crane are performed prior to use since it is not normally used or readily accessible except during refueling outages.

Element 7: Design of cranes to ANSI B30.2 or CMAA-70

All Callaway cranes were designed and built to specifications that explicitly referenced CMAA 70, "Specifications for Electric Overhead Traveling Cranes," and B30.2-1976 for design and construction requirements.

9.1.5.4.2 Reactor Vessel Head Lifting Procedures

Callaway Reactor Vessel Head lift procedures are described in Section 9.1.4.2.3.1, Phase II and Phase IV. The procedural controls on Reactor Vessel Head lifts are also subject to constraints on load height and weight that are bounded by the head drop analysis assumptions (for Westinghouse fuel, with the lift medium being air), as discussed in Section 4.2.b, Safety Evaluation 6.d of Section 9.1.4.3, Figure 9.1-25, and Table 9.1-9. As described in Reference 10, the analysis of a postulated drop of the RRVCH / IHA, which was performed in accordance with the guidance and acceptance criteria of NEI 08-05, concluded that the reactor vessel and its supports are qualified for an assumed drop height that exceeds the lift height allowed by procedure. This provides additional assurance that the core will remain covered and cooled in the event of a postulated RRVCH / IHA drop.

9.1.5.4.3 Single-Failure Proof Cranes for Spent Fuel Casks

The design of the single failure proof cask handling crane is described in Section 9.1.4.2.2. Callaway spent fuel cask lifting procedures are described in Section 9.1.4.2.3.1, Phase V. Safety Evaluation 6.c of Section 9.1.4.3 describes the facility design features that have been provided to assure safe handling of spent fuel casks.

9.1.5.5 Safety Evaluation

Control of heavy loads for the Callaway Plant in compliance with NUREG-0612 is defined by the Callaway Plant Lifting and Rigging Program. The Callaway Plant Lifting and Rigging Program includes a description of all cranes and hoists which may be used over spent fuel, fuel in the reactor core, or safe shutdown equipment.

The "SNUPPS Report on Control of Heavy Loads," as referenced in the Callaway Plant Lifting and Rigging Program, discusses Callaway's compliance with NUREG-0612 with regard to phase I and II. The report shows that a postulated heavy load drop would not result in damage to fuel or redundant safe shutdown equipment that would prevent safe shutdown of the plant. This is due to physical horizontal train separation provided by the plant layout, electrical and mechanical crane interlocks, or administrative control contained in plant procedures. Load drop analyses results are provided in the report and are also described in Section 9.1. An amended response to GL 81-07 (ULNRC-4056) was docketed by the NRC on July 27, 1999. Additional engineering calculations have been performed to document analyses of miscellaneous cranes and hoists that have subsequently been added to the plant, and which meet the criteria for inclusion in the program for control of heavy loads. An analysis (Reference 10) has also been performed in accordance with NEI 08-05 to establish a new licensing basis for heavy loads control during handling of the RRVCH / IHA, which have replaced the original Reactor Vessel Head.

In addition, an upgrade to the cask handling crane to make it single-failure proof has made the risk of a spent fuel cask drop extremely unlikely and acceptably low.

The Callaway Plant Lifting and Rigging Program complies with existing regulatory guidelines, and heavy load activities are performed within the existing licensing basis. Program commitments and requirements are controlled and maintained by plant procedures and the FSAR. No Technical Specifications exist relative to the control of heavy loads.

9.1.6 REFERENCES

1. Alexander, D. W., Shakely, R., and Dudek, D. F., "Reactor Vessel Head Drop Analysis," WCAP-9198, January, 1978.

2. Hunsaker, J. C. and Rightnire, B. G., Engineering Applications of Fluid Mechanics, page 183.

3. Hoemer, J. F., Fluid-Dynamic Drag, page 317.

4. Roark, R. J., Formulas For Stress and Strain - Fourth Edition, pages 340, 370, and 371.

5. Request for Resolution 09886A - Spent Fuel Pool Transfer Gate.

6. Union Electric Calculation KE-25, Spent Fuel Pool Transfer Gate Rigging.

7. RFR 4435C, Calculation BB-18, Rev. 0, Addenda 2, Reactor Head Drop Analysis.

8. Hankinson, M. F., Bogden, F. J., Ghergurovich, J. "Reactor Vessel Head Drop Analysis," WCAP-9198, Revision 1, October 2004.

9. NSAL 04-6, November 15, 2004, "Reactor Vessel Head Drop Analysis."

10. Calculation BB-18, Rev. 0, Addendum 3, "Evaluate the Impact to the Existing Head Drop Analyses Due to IHA Installation."

11. Holtec Final Safety Analysis Report for the HI-STORM UMAX Canister Storage System, Rev. 2

12. 10 CFR 72 Certificate of Compliance No. 1040, HI-STORM UMAX Canister Storage System, Amendment 0, dated April 6, 2015

13. 10 CFR 72.212 Evaluation Report, Callaway Plant Unit 1

TABLE 9.1-1 NEW FUEL STORAGE DESIGN DATA

Component Requirements	Design Data
New fuel storage vault capacity	66 new fuel assemblies (approximately 34% of a core)
New fuel storage vault size	21 feet - 0 inches wide, 24 feet - 10 inches long, 15 feet - 0 inches deep (clear dimensions)
Module array	Center-to-center cell lattice array is 21 x 21 inches with 33 dual cell modules which are arranged in three rows of 11 modules each.

TABLE 9.1-2 SPENT FUEL STORAGE DESIGN DATA

Component Requirements	Design Data
Type	High density
Fuel storage pool storage capacity	With the Callaway fuel storage pool rerack modification to the spent fuel pool in 1999, Callaway's total fuel storage space was expanded to a capability to store 2642 fuel assemblies. The fuel storage pool consists of the spent fuel pool and the cask loading pool (with fuel storage racks installed). The modification replaced the 12 original fuel storage racks with 15 high density storage racks. The license amendment in support of the rerack modification included and additional capability to add three high density storage racks within the cask loading pool during a future campaign. The three high density racks within the cask loading pool would be capable of storing 279 fuel assemblies. See Section 9.1.2.2.
Fuel storage pool size (does not include cask loading pool)	28 feet - 6 inches wide 50 feet - 0 inches long 41 feet - 0 inches deep
Module array	Refer to Figure 9.1-2.
Fuel storage pool design temperature, °F	170

TABLE 9.1-3 DESIGN COMPARISION TO REGULATORY POSITIONS OF REGULATORY GUIDE 1.13 REVISION 1, DATED DECEMBER 1975, TITLED "SPENT FUEL STORAGE FACILITY DESIGN BASIS"

Regulatory Guide 1.13 Position	Union Electric
1. The spent fuel storage facility (including its structures and equipment, except as noted in Paragraph 6 below) should be designed to Category I seismic requirements.	1. Complies as described in Section 9.1.2.1.1
2. The facility should be designed (a) to keep tornadic winds and missiles generated by these winds from the fuel storage pool and (b) to keep missiles generated by tornadic winds from contacting fuel within the pool.	2. Complies as described in Section 3.5, and 3.8.
3. Interlocks should be provided to prevent cranes from passing over stored fuel (or near stored fuel in a manner such that if a crane failed the load could tip over on stored fuel) when fuel handling is not in progress. During fuel handling operations, the interlocks may be bypassed and administrative control used to prevent the crane from carrying loads that are not necessary for fuel handling over the stored fuel or other prohibited areas. The facility should be designed to minimize the need for bypassing such interlocks.	3. Complies as described in Section 9.1.4.
4. A controlled leakage building should enclose the fuel pool. The building should be equipped with an appropriate ventilation and filtration system to limit the potential release of radioactive iodine and other radioactive materials. The building need not be designed to withstand extremely high winds, but leakage should be suitably controlled during refueling operations. The design of the ventilation and filtration system should be based on the assumption that the cladding of all of the fuel rods in one fuel bundle might be breached. The inventory of radioactive materials available for leakage from the building should be based on the assumptions given in Regulatory Guide 1.25, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors" (Safety Guide 25).	4. Complies as described in Section 9.4.2 and 15.7.4.

TABLE 9.1-3 (Sheet 2)

Regulatory Guide 1.13 Position	Union Electric
5. The spent fuel storage facility should have at least one of the following provisions with respect to the handling of heavy loads, including the refueling cask: a. Cranes capable of carrying heavy loads should be prevented, preferably by design rather than by interlocks, from moving into the vicinity of the pool; or b. Cranes should be designed to provide single-failure-proof handling of heavy loads, so that a single failure will not result in loss of capability of the crane-handling system to perform its safety function; or c. The fuel pool should be designed to withstand, without leakage that could uncover the fuel, the impact of the heaviest load to be carried by the crane from the maximum height to which it can be lifted. If this approach is used, design provisions should be made to prevent the crane, when carrying heavy loads, from moving in the vicinity of stored fuel.	5. Complies as described in Section 9.1.4.
6. Drains, permanently connected mechanical or hydraulic systems, and other features that by maloperation or failure could cause loss of coolant that would uncover fuel should not be installed or included in the design. Systems for maintaining water quality and quantity should be designed so that any maloperation or failure of such systems (including failures resulting from the safe shutdown earthquake) will not cause fuel to be uncovered. These systems need not otherwise meet Category I seismic requirements.	6. Complies as described in Section 9.1.2 and 9.1.3.
7. Reliable and frequently tested monitoring equipment should be provided to alarm both locally and in a continuously manned location if the water level in the fuel storage pool fails below a predetermined level or if high local-radiation levels are experienced. The high-radiation-level instrumentation should also actuate the filtration system.	7. Complies as described in Section 9.1.3.

TABLE 9.1-3 (Sheet 3)

Regulatory Guide 1.13 Position	Union Electric
8. A seismic Category I makeup system should be provided to add coolant to the pool. Appropriate redundancy or a backup system for filling the pool from a reliable source, such as a lake, river, or onsite seismic Category I water-storage facility, should be provided. If a backup system is used, it need not be a permanently installed system. The capacity of the makeup systems should be such that water can be supplied at a rate determined by consideration of the leakage rate that would be expected as the result of damage to the fuel storage pool from the dropping of loads, from earthquakes, or from missiles originating in high winds.	8. Complies as described in Section 9.1.3.

TABLE 9.1-4 FUEL POOL COOLING AND CLEANUP SYSTEM DESIGN PARAMETERS

1. Fuel storage pool storage capacity, assemblies

   Spent fuel pool = 2363
   Ultimate = 2642

2. Spent fuel pool water volume[(1)], (water level 1'-6" from top of pool)

   Nominal = 400,000 gallons

3. When fuel assemblies are stored in the fuel storage pool and a fuel storage pool verification has not been performed since the last movement of fuel assemblies in the fuel storage pool, the minimum Boron concentration of the spent fuel pool water = 2165 ppm.

4. Deleted

5. Heat Loads and Bulk Pool Temperatures (see Notes 2, 3, 4, 5, 6, and 7)

	Maximum Heat Rate (10^6 Btu/hr)	Bulk Pool Temp (°F)
Partial Offload	27.15	≤140
Full Core Offload	63.41	≤170

NOTES:

(1) For computation of thermal parameters, the fuel storage pool is considered isolated from the fuel transfer canal.

(2) The initial pool heatup rate is 8.0°F/hr, assuming that cooling is not in operation, and based upon a pool loading of 27.15 x 10^6 Btu/hr (partial offload).

(3) The initial pool heatup rate is 18.5°F/hr, assuming that cooling is not in operation, and based upon a pool loading of 63.41 10^6 Btu/hr (full core offload).

(4) Cycle specific analyses utilizing decay heat estimates based on ANSI/ANS-5.1-1979 verify that the maximum heat load is not exceeded.

(5) Bulk pool temperatures are based on the use of one 100-percent cooling water train with 105°F CCW with the following mass flow rates:

   Partial Offload: 1.5 x 10^6 lbm/hr
   Full Core Offload: 3.0 x 10^6 lbm/hr

TABLE 9.1-4 (Sheet 2)

(6) Spent fuel pool coolant mass flow rates assumed in the analysis are as follows:

Partial Offload: 1.625×10^6 lbm/hr
Full Core Offload: 1.95×10^6 lbm/hr

(7) See FSAR Section 9.1A.3 for explanation of how the Maximum Heat Rate is determined.

TABLE 9.1-5 FUEL POOL COOLING AND CLEANUP SYSTEM COMPONENT DESIGN PARAMETERS

Fuel Pool Cooling Pump	
Quantity	2
Type	Horizontal centrifugal
Design pressure, psig	150
Design temperature,°F	225
Design flow, gpm	3,250
Design head, ft	124
Material	Austenitic stainless steel
Design code	ASME Section III, Class 3
Motor data	150 hp/460 V/3 phase/60 Hz
Seismic category	I
Fuel Pool Skimmer Pump	
Quantity	1
Type	Inline centrifugal
Design pressure, psig	300
Design temperature,°F	160
Design flow, gpm	100
Design head, ft	156.7
Material	Austenitic stainless steel
Design code	MS
Fuel Pool Cleanup Pump	
Quantity	2
Type	Inline centrifugal
Design pressure, psig	300
Design temperature,°F	160

TABLE 9.1-5 (Sheet 2)

Design flow, gpm	150	
Design head, ft	161.4	
Material	Austenitic stainless steel	
Design code	MS	
Fuel Pool Cooling Heat Exchanger		
Quantity	2	
Design heat transfer, Btu/hr	15.09×10^6	
Heat transfer area: gross, ft^2	5270	
Design codes	ASME Section III Class 3 and TEMA "R"	
Seismic category	I	
	Shell	Tube
Design pressure, psig	150	150
Design temperature,°F	200	250
Design flow, gpm	3,000	3,250
Inlet temperature,°F	105	125
Outlet temperature,°F	115.1	115.7
Fluid circulated	Component cooling water	Fuel pool cooling water
Material	Carbon steel	Austenitic stainless steel
Fuel Pool Cleanup Demineralizer		
Quantity	1	
Design pressure, psig	150	
Design temperature,°F	250	
Design flow, gpm	300	
Resin volume, ft^3	145	

TABLE 9.1-5 (Sheet 3)

Design pressure drop (fouled), psi	12-15
Material	Austenitic stainless steel
Design code	ASME Section VIII, Div. 1
Fuel Pool Cleanup Filters	
Quantity	2
Design pressure, psig	150
Design temperature,°F	250
Design flow, gpm	150
Design pressure drop (clean/ fouled), psi	2/25
Filtration requirement	98% retention of particles above 3 microns (1)
Material, vessel	Austenitic stainless steel
Design code	ASME Section VIII, Div. 1
Fuel Pool Skimmer Filter	
Quantity	1
Design pressure, psig	150
Design temperature,°F	250
Design flow, gpm	100
Design pressure drop (clean/ fouled), psi	1/25
Filtration requirement	98% retention of particles above 30 microns (1)

(1) Filters may be downsized as operational needs dictate.

TABLE 9.1-6 FUEL STORAGE POOL COOLING AND CLEANUP SYSTEM SINGLE ACTIVE FAILURE

	Component	Failure	Comments
1.	FPC pump	Fail to start when manually started.	Two pumps are provided. One pump is sufficient for residual heat removal.
2.	Fuel storage pool level switch	Fails to stop pump upon low level in pool.	Two level switches are provided - one dedicated to each FPC pump. One switch is sufficient for protection of one pump.
3.	Motor-operated isolation valve for CCW outlet to FPC heat exchanger	Fails to close upon manual actuation prior to post-LOCA recirculation.	Two separate component cooling water loops are provided. One CCW loop provides 100 percent of post-LOCA cooling capacity.
		Fails to open upon manual actuation when fuel pool cooling heat load can be accepted after a LOCA.	Two separate cooling loops are provided. One loop provides 100 percent of residual heat removal.

TABLE 9.1-7 FUEL HANDLING CRANE DATA (1)

Parameters	Polar Crane	Cask Handling Crane (7)	Spent Fuel Pool Bridge Crane	Refueling Machine
	Name of Crane			
Capacity of main hoist	260 tons	125 tons	2 tons	2 tons
Capacity of auxiliary monorail hoist	25 tons	5 tons & 2 tons (2)		1.5 tons
Capacity of main trolley	260 tons	125 tons	2 tons	2.4 tons
Capacity of lift beam	500 tons			
Maximum main hoist speed	5 fpm	7.5 fpm & 5.0 fpm (6)	21 fpm	40 fpm
Minimum main hoist speed	3 ipm	0.25 fpm	7 fpm	
Maximum auxiliary monorail hoist speed	40 fpm			
Minimum auxiliary monorail hoist speed	3 fpm			
Maximum trolley speed	51.5 fpm	20 fpm	30 fpm	30 fpm
Minimum trolley speed	6 fpm	1.0 fpm	10 fpm	
Maximum bridge speed	51.5 fpm	20 fpm	30 fpm	60 fpm
Minimum bridge speed	6 fpm	1.0 fpm	10 fpm	
Maximum load during plant operation	190 tons	125 tons	1,870 lbs	2,900 lbs
Normal expected load range	0-190 tons	0-125 tons	0-1,870 lbs	
Maximum construction load	475 tons			
Maximum monorail hoist speed		20 fpm		22 fpm
Minimum monorail hoist speed		1 fpm		7 fpm
Maximum monorail trolley speed		30 fpm		
Minimum monorail trolley speed		1 fpm		

TABLE 9.1-7 (Sheet 2)

Parameters	Polar Crane	Cask Handling Crane (7)	Spent Fuel Pool Bridge Crane	Refueling Machine
	Name of Crane			
Main hoist lifting limitation	28 ft (5) (above vessel flange)	Cask bottom 9 inches above fl El. 2047'-6"	25' – 4" (Hook limit is 2066' 11-15/16"	
Seismic Class	(3)	(3)	(3)	(4)
Design Standards				
General	CMAA No. 70 (1975)	CMAA No. 70 (1975)	CMAA No. 70 (1975)	CMAA No. 70 (1975)
Structural	Covered by CMAA	Covered by CMAA	Covered by CMAA	Covered by CMAA
Electrical	NFPA Vol. 5 Art. 610 1974-1975	NFPA Vol. 5 Art. 610 1974-1975	NFPA Vol. 5 Art. 610 1974-1975	NFPA Vol. 5 Art. 610 1974-1975
Materials	ASTM Std's.	ASTM Std's.	ASTM Std's.	ASTM Std's.
Others	OSHA 29 CFR 1910 & 1926	OSHA 29 CFR 1910 & 1926 NOG-1 2004 NUREG-0554 NUREG-0612	OSHA 29 CFR 1910 & 1926	OSHA 29 CFR 1910 & 1926

NOTES:

(1) Rated speeds given are within 10 percent of the actual speeds.

(2) Refer to Figure 9.1-7: a 2-ton limit to the monorail hoist exists only over area B on Figure 9.1-7.

(3) Seismic Category I

(4) Component is non-Seismic Category I. Component is seismically designed and constructed per Position C.2 of Regulatory Guide 1.29.

(5) Height restricted due to ALARA concerns specified in Section 9.1.4.3.

(6) The 5.0 fpm limit to the main hoist speed is used during lifts at rated load.

TABLE 9.1-7 (Sheet 3)

Parameters	Name of Crane			
	Polar Crane	Cask Handling Crane (7)	Spent Fuel Pool Bridge Crane	Refueling Machine

(7) Hook limits in Figure 9.1-7 may be used if cask handling crane isin restricted path mode. Note that with the single failure proof cask handling crane, safe load paths include areas of the fuel building not restricted by the trolley/bridge mechanical stops, but exclude areas over the spent fuel pool and the new fuel storage area.

TABLE 9.1-8 DELETED

Table 9.1-8 has been deleted.

TABLE 9.1-9 WEIGHT OF INTEGRATED REACTOR VESSEL HEAD

Head	165,150	
CRDM (full length) - (1500 lb/mechanism; 53 mechanisms)	74,100	
Rod position indicator coil stacks	14,895	
Seismic platform	11,100	
Stud tensioner hoists	1,500	
Dummy cans	848	
Sling block platform	570	
Head insulation	1,700	
Lifting rig and vent shroud	20,375	
Studs, nuts and washers	37,150	
Head Shield System (primarily lead)	20,000	
Contingency	15,000	
	362,388	
Plus load block and bottom block assemblies	16,500	
Total	378,888	lbs

SUMMARY OF HEAD COMPONENT WEIGHTS BY MATERIAL

Steel (includes contingency and load block)	358,888	lbs
Lead	20,000	
Total	378,888	lbs

Notes:

This table reflects component weight values for the original reactor vessel head that are consistent with the design values by Westinghouse. These values were used in Calculation BB-18, Rev. 0, Addendum 2 (Reference 7). However, the calculations discussed in Section 9.1.4.3 use height and weight as variables to generate Figure 9.1-25. 381,274 lbs (previously evaluated) is bounded by inspection of Figure 9.1-25.

TABLE 9.1-10 DELETED

Table 9.1-10 has been deleted.

APPENDIX 9.1A - FUEL STORAGE POOL RACK ANALYSIS

9.1A.1 The HDR (High Density Rack) Design Concept

9.1A.1.1 Introduction

Historically, spent fuel rack designs have been based on conservative assumptions regarding criticality analyses. These analyses could be easily accommodated, since it was planned to store limited numbers of spent fuel assemblies on site. It was anticipated that only small numbers of spent fuel assemblies (1/4 to 1/2 of a full core load) would be stored in the spent fuel pool at any one time. Occasionally (e.g., for inservice inspection of the reactor vessel internals) the entire core would be unloaded and temporarily stored in the spent fuel pool. For these conditions, the fuel storage rack design was based on the conservative assumption that all fuel rack storage positions could be occupied by fresh unirradiated fuel assemblies of the highest initial enrichment that was foreseen as being usable in that facility.

The penalty in achievable fuel storage density associated with this conservative design assumption was relatively small under the circumstances anticipated and easily accommodated by a conservative fuel rack design. The potential penalty associated with this conservative design basis is no longer small when long-term on-site storage of spent fuel is a possibility.

There is no situation where more than one full core load of fresh unirradiated fuel assemblies is to be stored in the fuel storage pool. Therefore, it is unnecessary and wasteful to base the entire fuel storage rack design on the assumption of unirradiated fuel of the highest initial enrichment.

In the High Density Rack (HDR) design, each fuel pool storage rack location is designated as either Region 1, Region 2, Region 3, or empty (in the checkerboarding configuration). Numerous configurations of region designation are possible. Criteria are established for determining an acceptable configuration. The HDRs will store a maximum of 2363 fuel assemblies in the spent fuel pool and potentially an additional 279 fuel assemblies in the cask loading pool (with racks installed). Full-core offload capability will be maintained. The fuel storage pool consists of the spent fuel pool and the cask loading pool (with racks installed).

Region 1 locations are designed to accommodate new fuel with a nominal maximum enrichment of 4.6 wt%U-235 with no integral fuel burnable absorber (IFBA); or up to a nominal enrichment of 5.0 wt%U-235 with 16 IFBA; or spent fuel regardless of the discharge burnup.

Region 2 and 3 locations are designed to accommodate fuel of various initial enrichments which have accummulated minimum burnups within the acceptable domain

according to Figure 9.1A-3. Locations designated as empty cells contain no fuel assemblies.

9.1A.1.2 Design Bases

The high density fuel storage racks are designed to assure that the effective neutron multiplication factor (k_{eff}) in the fuel storage pool is equal to or less than 0.95 with the racks fully loaded with fuel of the highest anticipated reactivity, and flooded with unborated water at the temperature within the operating range corresponding to the highest reactivity. The fuel storage racks are designed to accommodate any and all of the following Westinghouse fuel assembly types: 17x17 OFA, 17x17 Standard, and 17x17 Vantage 5H (V5H), with a maximum nominal initial enrichment of 5.0 wt% ^{235}U and a minimum of 16 Integral Fuel Burnable Absorber (IFBA) rods. The OFA designation is used generically throughout this discussion and includes V-5 and V+ fuel. Additional restrictions are specified to allow the storage of these fuel assembly types without IFBA rods. FSAR Section 9.1A.5 lists the applicable codes, standards, and regulations or pertinent sections thereof relied on for the criticality safety analysis.

The maximum calculated reactivity includes a margin for uncertainty in reactivity calculations including mechanical tolerances. All uncertainties are statistically combined, such that the final k_{eff} will be equal to or less than 0.95 with a 95% probability at a 95% confidence level. Enrichments less than 5.0 wt% ^{235}U are also evaluated, and soluble boron concentrations necessary to protect against postulated accidents are determined. USNRC guidelines and the applicable ANSI standards specify that the maximum effective multiplication factor, k_{eff} , including bias, uncertainties, and calculational statistics, shall be less than or equal to 0.95, with 95% probability at the 95% confidence level. To assure that reactivity in the fuel storage pool is always less than the calculated maximum reactivity, the following conservative assumptions were made in performing the criticality safety analysis:

- Moderator is unborated water at a temperature that results in the highest reactivity (4°C, corresponding to the maximum possible moderator density).

- No soluble poison or control rods are assumed to be present for normal operations, although the additional margin due to the presence of soluble boron is identified.

- The effective multiplication factor of an infinite radial array of fuel assemblies was used except for the assessment of peripheral effects and certain abnormal/accident conditions where neutron leakage is inherent.

- Neutron absorption in minor structural members is conservatively neglected, i.e., spacer grids are replaced by water.

- Depletion calculations assume conservative operating conditions; highest fuel and moderator temperature and an allowance for the soluble boron concentrations during in-core operation.

- The assemblies with IFBA rods are assumed to contain the minimum possible number of IFBA rods (i.e., 16), in a conservative loading pattern, with a conservative length of 120 inches Further, the IFBA loading used in the analyses is reduced by an uncertainty of 5%.

9.1A.1.3 Design Description

Because the fuel storage racks are designed to accommodate any and all of the following Westinghouse fuel assembly types: 17x17 OFA, 17x17 Standard, and 17x17 Vantage 5H (V5H), with a maximum initial enrichment of 5.0 wt% ^{235}U, the most reactive assembly type was identified via independent criticality calculations. To assure the acceptability of the racks for storage of any and all of these assembly types, the most reactive assembly is used in the criticality analyses. At zero burnup, the 17x17 OFA assembly has the greatest reactivity in the storage racks, and is therefore used as the design basis fuel assembly.

The Mixed-Zone Three-Region (MZTR) configuration uses fuel assemblies with high discharge burnup as barrier fuel to isolate fresh fuel assemblies in order to achieve an acceptable k_{eff} in the fuel storage pool. Three separate storage regions are provided, with independent criteria defining the highest potential reactivity in each of the three regions:

- Region 1 is designed to accommodate new un-irradiated (fresh) fuel with a maximum nominal enrichment of 5.0 wt% ^{235}U and a minimum of 16 IFBA rods, or fuel of equivalent reactivity (e.g., 4.6 wt% ^{235}U maximum enrichment without IFBA rods). Further, Region 1 cells on the periphery of the pool, that are adjacent to a concrete wall, may accommodate fresh fuel assemblies with maximum nominal enrichment of 5.0 wt% ^{235}U and no IFBA rods.

- Region 2 is designed to accommodate fuel with a maximum nominal initial enrichment of 5.0 wt% ^{235}U and high ($\geq$ 50 MWd/kgU) discharge fuel burnup, or fuel of initial enrichment and burnup combinations yielding an equivalent reactivity. Region 2 locations are used to isolate Region 1 fuel assemblies from other Region 1 and Region 3 fuel assemblies.

- Region 3 is designed to accommodate fuel with a maximum nominal initial enrichment of 5.0 wt% ^{235}U and typical (40.75 $\leq$ burnup $\leq$ 50 MWd/kgU) discharge fuel burnup, but can accommodate any spent fuel with discharge fuel burnup greater than or equal to 40.75 MWd/kgU. Additionally, fuel of

initial enrichment and burnup combinations yielding an equivalent reactivity are acceptable for storage in Region 3.

The water in the spent fuel storage pool normally contains soluble boron. The presence of this soluble boron results in a large sub-criticality margin under actual operating conditions. However, NRC guidelines specify that the criticality limit, $k_{eff} \leq 0.95$ for normal storage, remain valid under accident conditions that also assume the loss of all soluble boron in the fuel storage pool. Under the double contingency principle given in ANSI N-16.1-1975 (Reference 6) and in the April 1978 NRC letter (Reference 3), credit for soluble boron under abnormal or accident conditions, however, is allowed, because only a single independent accident need be considered at one time.

The consequences of abnormal and accident conditions are evaluated for the fuel storage pool. "Abnormal" refers to conditions which may reasonably be expected to occur during the lifetime of the plant, and "accident" refers to conditions which are not expected to occur, but nevertheless must be protected against.

9.1A.2 Criticality Analyses for the Fuel Storage Pool

9.1A.2.1 Description of Fuel Storage Pool Conditions

9.1A.2.1.1 Normal Operating Conditions

In the MZTR configuration, the fresh fuel cells (Region 1) are located alternately along the periphery of the fuel storage pool (where neutron leakage reduces reactivity) or along the boundary between two storage modules (where the water gap provides a flux-trap which reduces reactivity). High burnup fuel in Region 2 affords a low-reactivity barrier between fresh fuel assemblies and Region 3 fuel of intermediate burnup.

Numerous configurations of the various assemblies within the fuel storage pool are possible. The criteria for determining an acceptable loading arrangement in the MZTR configuration for fuel of different burnups are as follows:

- Region 1 cells are only located along the outside periphery of the storage modules and must be separated by one or more Region 2 (burnup > or = 50 MWd/kgU for 5.0 wt% ^{235}U, or equivalent burnup/enrichment combinations) cells.

- Region 1 cells may be located directly across from one another when separated by a water gap. Along the interface between storage modules the water gap is 1.5" +/- 1/8" (excluding sheathing).

- The outer rows of alternating Region 1 and Region 2 cells must be further separated (isolated) from the internal Region 3 cells by one or more Region 2 cells.

- Fresh fuel assemblies without IFBA rods and a maximum enrichment of 5.0 wt% ^{235}U may be stored in any periphery Region 1 cell location that is next to a concrete wall.

Prior to approaching the reactor end-of-life, not all storage cells are needed for spent fuel. Therefore, an alternative (interim) configuration may be used in which the cells of selected modules may be loaded in a checkerboard pattern of fresh fuel (or spent fuel of any burnup) with empty cells. A checkerboard configuration is intended primarily to develop a simple configuration of Region 1 cells and facilitate storage of fresh (unburned) and low burnup fuel.

The principles involved in the design and specification of an acceptable loading arrangement in the interim checkerboard configuration are as follows:

- Fuel with maximum nominal enrichment of 5 wt% ^{235}U and a minimum of 16 IFBA rods, or fuel of equivalent reactivity (e.g., 4.6 wt% ^{235}U maximum enrichment without IFBA rods), is placed in an alternating checkerboard style pattern with empty cells (i.e., fuel assemblies are surrounded on all four sides by empty cells).

- Fuel assemblies may not be located directly across from one another, even when separated by a water gap.

- So long as the checkerboard pattern is maintained in a linear array greater than or equal to 2$\times$2, the arrangement may be used anywhere in the pool. More than one checkerboard pattern may be used, as long as the limitations discussed herein are adhered to.

- A checkerboard region may be bounded by either a water gap, empty rack cells, Region 2 fuel assemblies, or Region 3 fuel assemblies.

- MZTR and checkerboard storage shall not be developed within the same rack.

Non-Fueled items such as trash baskets and dummy fuel assemblies may be stored anywhere in the fuel storage pool. Damaged fuel storage baskets must be stored in any cell that allows fuel assembly storage.

Figure 9.1A-3 defines the acceptable burnup domains for spent fuel and illustrates the limiting burnup for fuel of various initial enrichments for both Region 2 (upper curve) and Region 3 (lower curve). Both curves assume that the fresh fuel (Region 1) has a maximum nominal enrichment of 5.0 wt% ^{235}U. Criticality analyses demonstrate that the most reactive configuration occurs along the boundary between modules where the water gap affords a neutron flux trap. Along the periphery of the modules facing the concrete wall of the pool, the reactivity is substantially lower due to neutron leakage.

The bounding criticality analyses are summarized in Table 9.1A-1 for the design basis MZTR storage configuration and in Table 9.1A-2 for the interim checkerboard storage configuration. In both cases, the single accident condition of the loss of all soluble boron is assumed. The calculated maximum reactivity of 0.943 (corresponding to the design basis MZTR storage configuration) is within the regulatory limit of 0.95. This maximum reactivity includes calculational uncertainties and uncertainties in reactivity due to manufacturing tolerances (95% probability at the 95% confidence level), an allowance for uncertainty in depletion calculations, and the evaluated effect of the axial distribution in burnup.

The value of k_{eff} in Table 9.1A-1 assumes no soluble boron to be present. For normal operations, a minimum soluble boron concentration of 2165 ppm is maintained in the Callaway fuel storage pool. This concentration of soluble boron provides a large safety margin for sub-criticality.

As cooling time increases in long-term storage, decay of 241Pu (and growth of 241Am) results in a continuous decrease in reactivity, which provides an increasing sub-criticality margin with time. No credit is taken for this decrease in reactivity other than to indicate conservatism in the calculations.

The burnup criteria identified in Figure 9.1A-3, for acceptable storage in Region 2 and Region 3, are used in appropriate administrative procedures to assure verified burnup as specified in the proposed Regulatory Guide 1.13, Revision 2 (Reference 4). Soluble poison is present in the pool water during fuel handling operations, and this serves as a further margin of safety and as a precaution in the event of fuel misplacement during fuel handling operations.

9.1A.2.1.2 Abnormal and Accident Conditions

Although credit for the soluble poison normally present in the fuel storage pool water is permitted under abnormal or accident conditions, most abnormal or accident conditions will not result in exceeding the limiting reactivity (k_{eff} of 0.95) even in the absence of soluble poison. The effects on reactivity of credible abnormal and accident conditions are discussed in Section 9.1A.2.2.5 and summarized in Table 9.1A-3. Of these abnormal or accident conditions, only two have the potential for a more than negligible positive reactivity effect. These include: (1) the inadvertent misplacement of a fresh fuel assembly and (2) the mis-location of a fresh fuel assembly into a position external and adjacent to a storage rack.

The inadvertent misplacement of a fresh fuel assembly has the potential for exceeding the limiting reactivity, should there be a concurrent and independent accident condition resulting in the loss of all soluble poison. Assuring the presence of soluble poison will preclude the simultaneous occurrence of the two independent accident conditions during fuel handling operations. The largest reactivity increase would occur if a fresh fuel assembly of 5.0 wt% ^{235}U enrichment were to be inadvertently loaded into an empty cell

in the checkerboard configuration with the remainder of the rack fully loaded with fuel of the highest permissible reactivity. For the MZTR configuration, when a fresh fuel assembly of 5.0 wt% ^{235}U enrichment is inadvertently loaded into a Region 2 location (with the remainder of the rack fully loaded with fuel of the highest permissible reactivity), the overall reactivity is slightly less reactive. However, it still exceeds the limiting value without the presence of soluble boron. Under these accident conditions, credit for the presence of soluble poison is permitted by the NRC guidelines. Calculations indicate that 500 ppm soluble boron would be adequate to reduce the k_{eff} to below the reference k_{eff} value (Table 9.1A-1). This soluble boron concentration bounds all other accidents and is well below the 2165 ppm soluble boron concentration that is maintained in both the Callaway fuel storoage pool.

It is possible for a fuel assembly to be dropped or mis-located in the fuel storage pool such that it may be situated outside and adjacent to a storage rack. The calculated k_{eff} value for the worst case situation exceeds the limit on reactivity in the absence of soluble boron. Because this case is less severe than the misplaced fresh fuel assembly accident, it requires less than 500 ppm soluble boron to reduce the k_{eff} to the reference value (Table 9.1A-1).

9.1A.2.2 Analytical Methodology

To assure the acceptability of the racks for storage of all fuel assembly design types, the most reactive assembly type was identified by independent criticality calculations. This most reactive assembly is the reference assembly used in the criticality calculations. In addition a nominal fuel storage cell is also used in the criticality calculations. This nominal fuel storage cell represents the fuel pool storage cells.

9.1A.2.2.1 Reference Fuel Assembly

The fuel storage pool racks are designed to accommodate any and all of the following Westinghouse fuel assembly types: 17x17 OFA, 17x17 Standard, and 17x17 Vantage 5H (V5H), with a maximum nominal initial enrichment of 5.0 wt% ^{235}U. Additional restrictions are specified to allow the storage of any of the aforementioned fuel assembly types without IFBA rods. Independent criticality calculations were performed to identify the most reactive assembly type. The results of these calculations show that at zero burnup the 17x17 OFA assembly has the greatest reactivity in the storage racks, and thus, is the design basis fuel assembly. The Westinghouse OFA is a 17 x 17 array of fuel rods with 25 rods replaced by 24 control rod guide tubes and 1 instrument thimble. Table 9.1A-4 summarizes the fuel assembly design specifications.

At burnups beyond approximately 25 MWd/kgU, the 17x17 Standard and 17x17 Vantage 5H become the most reactive assembly types. These two assembly types are essentially identical. Therefore, for the determination of the equivalent enrichments associated with Regions 2 and 3, the reactivity of the V5H assembly was related to an initial enrichment for the 17x17 OFA assembly.

The fresh fuel assemblies were assumed to contain the minimum possible number of IFBA rods (i.e., 16) in a conservative loading pattern with a conservative length of 120 inches. The IFBA rods are characterized by a thin ZrB_2 coating on the outside of the fuel pellets. Because B-10 in ZrB_2 is a strong neutron absorber, it reduces the assembly reactivity, and thus, enables the storage of fuel with high initial enrichment. The IFBA loading was assumed to be 2.25 mg B-10/inch with an uncertainty of 5%. The IFBA loading was assumed to be reduced by the 5% uncertainty in this analysis. With 16 IFBA rods present, the reactivity of the assembly does not exhibit a peak with burnup, and thus the calculated reactivity of the fresh assembly is bounding. The IFBA rods are modeled in the fresh fuel assemblies only; no credit is taken for residual IFBA in the Region 2 and Region 3 fuel assemblies.

9.1A.2.2.2 <u>High Density Reference Fuel Storage Cell</u>

A nominal fuel storage pool cell was used for the criticality calculations for the fuel storage pool cells. Stainless steel boxes are arranged in an alternating pattern such that the connection of the box corners form storage cells between those of the stainless steel boxes. The walls of the stainless steel boxes contain a boral panel (attached by a stainless steel sheathing) centered on each side. Peripheral cells use stainless steel sheathing on the outside wall to attach the Boral panel. The fuel assemblies are normally located in the center of each storage cell on a nominal lattice spacing of 8.99 inches.

9.1A.2.2.3 <u>Analytical Technique</u>

The principal method for criticality analysis of the high density storage racks is the three-dimensional Monte Carlo KENO5a (Reference 1) code, as developed by the Oak Ridge National Laboratory as part of the SCALE 4.3 package. Independent verification calculations were performed with the MCNP (version 4a) code (Reference 2), a continuous energy three-dimensional Monte Carlo code developed at the Los Alamos National Laboratory. The KENO5a calculations used the 238-group SCALE cross-section library and NITAWL (Reference3) for ^{238}U resonance shielding effects (Nordheim integral treatment). Benchmark calculations, presented in section 9.1A.2.2.6, indicate a bias of 0.0030 with an uncertainty of 0.0012 for KENO5a and 0.0009 ± 0.0011 for MCNP4a, both evaluated at the 95% probability, 95% confidence level (Reference 4).

Fuel depletion analyses during core operation were performed with CASMO-3, a two-dimensional multigroup transport theory code based on capture probabilities (References 5-7). Restarting the CASMO-3 calculations in the storage rack geometry at 4-C yields the two-dimensional infinite multiplication factor (k_{∞}) for the storage rack. Parallel calculations with CASMO-3 for the storage rack at various enrichments enable a reactivity equivalent enrichment (fresh fuel) to be determined that provides the same reactivity in the rack as the depleted fuel. CASMO-3 was also used to determine the small reactivity uncertainties (differential calculations) of manufacturing tolerances.

In the geometric models used for the calculations, each fuel rod and its cladding were described explicitly and reflecting boundary conditions were used in the radial direction which has the effect of creating an infinite radial array of storage cells. KENO5a and MCNP4a Monte Carlo calculations inherently include a statistical uncertainty due to the random nature of neutron tracking. To minimize the statistical uncertainty of the KENO5a-calculated reactivity and to assure convergence, a minimum of 5 million neutron histories in 1,000 generations of 5,000 neutrons per generation were accumulated in each single assembly infinite array calculation. A minimum of 20 million neutron histories in 2,000 generations of 10,000 neutrons per generation were accumulated in each multiple assembly (MZTR and checkerboard) configuration.

Figure 9.1A-1 represents the reference MZTR geometric model used in the KENO5a calculations. This figure is intended to show the arrangement of fuel assemblies modeled, and not the specific details of the model. With reflecting boundary conditions, this model effectively describes the entire pool in the MZTR configuration, including the water gap between storage modules. In the axial direction, the full length 144-inch fuel assembly was described assuming 30-cm water reflector, top and bottom. In addition, the axial variation in burnup was explicitly modeled and resulted in a slightly lower reactivity than the reference design calculation (which assumes uniform axial burnup). Figure 9.1A-2 represents the reference checkerboard geometric model used in the KENO5a calculations. With reflecting boundary conditions, this model effectively describes the entire pool in the checkerboard configuration, including the water gap between storage modules. These large models were also used to investigate uncertainties in the configurations and the consequences of potential accident conditions, including a misplaced fresh fuel assembly.

Because NITAWL-KENO5a does not have burnup capability, burned fuel was represented by fuel of equivalent enrichment as determined by CASMO-3 calculations in the storage cell (i.e. an enrichment which yields the same reactivity in the storage cell as the burned fuel). In tracking long-term (30-year) reactivity effects of spent fuel, previous CASMO-3 calculations have demonstrated a continuous reduction in reactivity with time (after Xe decay) (Reference 8) due primarily to ^{241}Pu decay and ^{241}Am growth.

9.1A.2.2.3.1 Fuel Burnup Calculations and Uncertainties

CASMO-3 was used for burnup calculations in the hot operating condition. CASMO-3 has been extensively benchmarked (References 7 and 9) against cold, clean, critical experiments (including plutonium-bearing fuel), Monte Carlo calculations, reactor operations, and heavy element concentrations in irradiated fuel. In addition to burnup calculations, CASMO-3 was used for evaluating the small reactivity increments (by differential calculations) associated with manufacturing tolerances and for determining temperature effects.

In the CASMO-3 geometric model, each fuel rod and its cladding were described explicitly and reflective boundary conditions were used at the centerline of the Boral and steel plates between storage cells. These boundary conditions have the effect of

creating an infinite array of storage cells in the X-Y plane and provide a conservative estimate of the uncertainties in reactivity attributed to manufacturing tolerances.

Conservative assumptions of moderator and fuel temperatures and the average operating soluble boron concentrations were used to assure the highest plutonium production and hence conservatively high values of reactivity during burnup. Since critical experiment data with spent fuel is not available for determining the uncertainty in depletion calculations, an allowance for uncertainty in reactivity was assigned based upon the assumption of 5% uncertainty in burnup. At the design basis burnups of 40.75 and 50 MWd/kgU, the uncertainties in burnup are ± 2.04 and ± 2.5 MWd/kgU respectively. These uncertainties correspond to approximately 0.013 Δk and 0.016 Δk in the fuel infinite multiplication factor. (The majority of the uncertainty in depletion calculations derives from uncertainties in fuel and moderator temperatures and the effect of reactivity control methods (e.g., soluble boron). For depletion calculations, bounding values of these operating parameters were assumed to assure conservative results in the analyses).

To evaluate the reactivity consequences of the uncertainties in burnup, independent MZTR calculations were made with fuel of 38.5 and 47.5 MWd/kgU burnup in Regions 2 and 3, and the incremental change from the reference burnups assumed to represent the net uncertainties in reactivity attributable to uncertainty in depletion calculations. These calculations resulted in an incremental reactivity uncertainty in k_{eff} of ± 0.0056 Δk for Region 2 and ± 0.0001 Δk for Region 3. These effects would be lower for lower initial enrichments and burnups. The fresh unburned fuel in Region 1 strongly dominates the reactivity which tends to minimize the reactivity consequences of uncertainties in depletion calculations. The allowance for uncertainty in the burnup calculations is believed to be conservative, particularly in view of the substantial reactivity decrease with time as the spent fuel ages.

9.1A.2.2.3.2 Effect of Axial Burnup Distribution

Initially, fuel loaded into the reactor will burn with a slightly skewed cosine power distribution. As burnup progresses, the burnup distribution will tend to flatten, becoming more highly burned in the central regions than in the upper and lower regions. At high burnup, the more reactive fuel near the ends of the fuel assembly (less than average burnup) occurs in regions of high neutron leakage. Consequently, it is expected that over most of the burnup history, fuel assemblies with distributed burnups will exhibit a slightly lower reactivity than that calculated for the uniform average burnup. As burnup progresses, the distribution, to some extent, tends to be self-regulating as controlled by the axial power distribution, precluding the existence of large regions of significantly reduced burnup. Among others, Turner (Reference 10) has provided generic analytic results of the axial burnup effect based upon calculated and measured axial burnup distributions. These analyses confirm the minor and generally negative reactivity effect of the axially distributed burnup.

Based on axial burnup distributions of spent fuel (axial burnup data for assemblies from the Callaway plant with average burnups of 50.10 and 36.84 MWd/kgU were normalized to the Region 2 and 3 burnups, 50 and 40.75 MWd/kgU, respectively), three-dimensional KENO5a calculations were performed. In these calculations, the axial height of the Region 2 and 3 fuel was divided into 5 axial zones, each with an average enrichment equivalent to the burnup of that zone. The selection of the five axial zones was based on the shapes of the axial burnup distributions. The resulting k_{eff} was 0.007 Δk less than the reference k_{eff} (which assumes uniform axial burnup). Fuel of lower initial enrichments (and lower burnup) would have a more negative reactivity effect as a result of the axial variation in burnup. These estimates are believed to be conservative since smaller axial increments in the calculations have been shown to result in lower incremental reactivities (Reference 10).

9.1A.2.2.4 Criticality Analyses Uncertainties and Tolerances

A number of tolerances result in reactivity uncertainties which must be considered in the criticality analyses.

9.1A.2.2.4.1 Nominal Design

For the nominal MZTR storage configuration, the bounding criticality analyses are summarized in Table 9.1A-1. The NITAWL-KENO5a calculated k_{eff} value is combined with all the known uncertainties and corrected for bias and temperature (see Section 9.1A.2.2.5.1 for temperature correction), to determine the maximum k_{eff} value with a 95% probability at the 95% confidence level (Reference 4).

For the interim loading pattern of fresh fuel checkerboarded with empty cells, the bounding criticality analyses are summarized in Table 9.1A-2. An alternate calculation with a 2×2 checkerboard pattern bordered on all sides with Region 3 fuel assemblies resulted in a maximum k_{eff} of 0.903 with a 95% probability at the 95% confidence level. Therefore, the checkerboard loading pattern may be used anywhere in any module provided that the checkerboard pattern is a linear array greater than or equal to 2×2 and is bordered by any of the following: the water gap between rack modules, the water gap between a rack module and the pool wall, empty rack cells, Region 2 fuel assemblies, and/or Region 3 fuel assemblies.

9.1A.2.2.4.2 Uncertainties Due to Manufacturing Tolerances

The uncertainties due to manufacturing tolerances are summarized in Table 9.1A-5 and discussed below.

9.1A.2.2.4.2.1 Boron Loading Tolerances

The Boral absorber panels are manufactured with a tolerance limit in B-10 content which assures that at any point, the minimum B-10 areal density will not be less than 0.030 g/

cm^2. Differential CASMO-3 calculations for an infinite array of fresh assemblies with the minimum tolerance B-10 loading results in an incremental reactivity uncertainty of ± 0.0044 Δk. This value was conservatively assumed to be the B-10 loading uncertainty.

9.1A.2.2.4.2.2 Boral Width Tolerance

The differential CASMO-3 calculated reactivity uncertainty is ± 0.0010 Δk, when the reference storage cell design has the minimum tolerance for Boral panel thickness.

9.1A.2.2.4.2.3 Tolerances in Cell Lattice Spacing

The differential CASMO-3 calculations determine an uncertainty of ± 0.0016 k in the calculated reactivity when the minimum manufacturing tolerance on the inner box dimension is used. The minimum manufacturing tolerance on the inner box dimension directly affects the storage cell lattice spacing between fuel assemblies.

9.1A.2.2.4.2.4 Stainless Steel Thickness Tolerances

The nominal stainless steel thickness for the stainless steel box also has an impact on the calculation of reactivity. The reactivity uncertainty of the expected stainless steel thickness tolerances was calculated with CASMO-3 and was determined to be ± 0.0002 Δk.

9.1A.2.2.4.2.5 Fuel Enrichment and Density Tolerances

The design maximum enrichment is 5.0 ± 0.05 wt% ^{235}U. Separate CASMO-3 burnup calculations were made for fuel of the maximum enrichment (5.05 wt% ^{235}U) and for the maximum UO_2 density (10.61 g/cm^3). Reactivities in the storage cell were then calculated using the restart capability in CASMO-3. For fresh fuel, the incremental reactivity uncertainties were ± 0.0023 Δk for the enrichment tolerance and ± 0.0026 Δk for the tolerance in fuel density.

9.1A.2.2.4.3 Water-Gap Spacing Between Modules

The water-gap between modules, which is 1.5 inches (excluding sheathing), constitutes a neutron flux-trap for the storage cells of facing racks. KENO5a calculations were made with the reference MZTR model to determine the uncertainty associated with a water-gap tolerance. Due to the asymmetries in the MZTR pool configuration, the effect of the horizontal and vertical water gaps (see Figure 9.1A-1) were calculated separately. From these calculations, it was determined that the incremental reactivity consequence (uncertainty) for a water-gap tolerance of ± 1/8 inches is ± 0.0014 Δk (horizontal gap) and ± 0.0003 Δk (vertical gap). The racks are constructed with the base plate extending beyond the edge of the cells which assures that the minimum spacing between storage modules is maintained under all credible conditions.

9.1A.2.2.4.4 Eccentric Fuel Positioning

The fuel assembly is assumed to be centered in the storage rack cell. Calculations were made using KENO5a assuming the fuel assemblies were located in the corners of the storage rack cells (four-assembly clusters at the closest possible approach). These calculations indicated that the reactivity effect is small and negative. Therefore, the reference case in which the fuel assemblies are centered is controlling and no uncertainty for eccentricity is necessary.

9.1A.2.2.5 Abnormal and Accident Conditions

The reactivity effects of abnormal and accident conditions are summarized in Table 9.1A-3.

9.1A.2.2.5.1 Temperature and Water Density Effects

The moderator temperature coefficient of reactivity is negative; a moderator temperature of 4°C (39°F) was assumed for the reference calculations, which assures that the true reactivity will always be lower over the expected range of water temperatures. Temperature effects on reactivity have been calculated (CASMO-3) and the results are shown in Table 9.1A-6. In addition, the introduction of voids in the water internal to the storage cell (to simulate boiling) decreased reactivity, as shown in Table 9.1A-6.

With soluble boron present, the temperature coefficients of reactivity would differ from those listed in Table 9.1A-6. However, the reactivities would also be substantially lower at all temperatures with soluble boron present. The data in Table 9.1A-6 is pertinent to the higher-reactivity unborated case.

For the dominant Region 1 fuel, the value of Δk between calculations at 20°C and 4°C is 0.0020 Δk. Since the KENO5a code cannot properly handle temperature dependence, all KENO5a calculations were performed at 20°C and a temperature correction factor (+0.0020 Δk) was applied to the results.

9.1A.2.2.5.2 Lateral Rack Movement

The possibility of reductions in the rack-to-rack gaps and the resulting criticality consequences have also been reviewed. Criticality evaluations are sensitive to these gap dimensions, since the inter-rack gaps provide a flux trap which reduces the reactivity. Rack to rack gap reductions are a concern subsequent to dynamic events which are severe enough to displace the racks laterally or produce fuel to rack cell wall impacts of sufficient magnitude to exceed cell wall material yield strength (i.e., produce plastic deformation).

The criticality analyses are based on the minimum nominal rack to rack gap of 1.5 inches (excluding sheathing). Thus, the outer sheathing wall-to-outer sheathing wall gap is 1.35 inches. This gap dimension is maintained during initial installation and subsequent to

dynamic loadings, and is ensured by fabrication of the 3/4 inch base plate extensions on each rack.

Momentary reductions in these gaps may be caused by the swaying of the tops of the racks during seismic events, during which the tops of the cells may actually come into contact. Even under these circumstances, the bottoms of the cells in adjacent racks are still maintained at the 1.5 inch dimension due to the base-plate extensions. Transient reduction in the inter-rack gap dimension below 1.5 inches is acceptable because of the presence of soluble boron which may be credited during seismic events. Additionally, a time-history plot of the inter-rack gaps (see Figure 9.1A-25 through Figure 9.1A-27) indicates that the gaps are reduced for a very short period of time before being restored to the minimum of 1.5 inches.

9.1A.2.2.5.3 Rack-Gap Changes

Another consideration which could potentially reduce the inter-rack gap is the impact of the fuel assembly on the inside of the cell wall during seismic events. If these impacts are of sufficient magnitude to allow plastic deformation of the cell wall membrane, then permanent displacement of the cell would take place, thus reducing the inter-rack gap. The largest fuel assembly to cell wall impact load is determined to be 840 pounds (see FSAR Section 9.1A.4.3.4.6). Evaluations on the local cell wall integrity (see FSAR Section 9.1A.4.3.5.3) have determined that the load required to produce permanent deformation (i.e., exceed the cell membrane material yield strength) exceeds the calculated load of 840 pounds by a factor of approximately 4. Therefore, there are no criticality concerns related to the reductions in inter-rack gaps from plastic deformation of the cell wall.

9.1A.2.2.5.4 Abnormal Location of a Fuel Assembly

In the MZTR configuration, the abnormal location of a fresh unirradiated fuel assembly of 5.0 wt% ^{235}U enrichment could, in the absence of soluble poison, result in exceeding the design reactivity limitation (k_{eff} of 0.95). This would occur if a fresh fuel assembly of the highest permissible enrichment were to be inadvertently loaded into either a Region 2 or Region 3 storage cell. Calculations (KENO5a) confirmed that the highest reactivity, including uncertainties, for the worst case postulated accident condition (fresh fuel assembly in Region 2) would exceed the limit on reactivity in the absence of soluble boron. Soluble boron in the spent fuel pool water, for which credit is permitted under these accident conditions, would assure that the reactivity is maintained substantially less than the design limitation. Calculations indicate that a soluble poison concentration of 440 ppm boron would be required to limit the maximum reactivity to the reference k_{eff} value (Table 9.1A-1), including all uncertainties and biases, under this maximum postulated accident condition.

In the checkerboard configuration, the worst case postulated accident condition (fresh fuel assembly inadvertently loaded into an empty cell) would also exceed the limit on

reactivity in the absence of soluble boron. Soluble boron in the spent fuel pool water, for which credit is permitted under these accident conditions, would assure that the reactivity is maintained substantially less than the design limitation. Calculations indicate that a soluble poison concentration of 500 ppm boron would be required to limit the maximum reactivity to the reference k_{eff} value (Table 9.1A-1), including all uncertainties and biases, under this maximum postulated accident condition.

9.1A.2.2.5.5 Dropped Fuel Assembly

For the case in which a fuel assembly is assumed to be dropped on top of a rack, the fuel assembly will come to rest horizontally on top of the rack with a minimum separation distance from the active fuel in the rack of more than 12 inches, including the potential deformation under seismic or accident conditions. At this separation distance, the effect on reactivity is insignificant. Furthermore, the soluble boron in the pool water assures that the true reactivity is always less than the limiting value for this dropped fuel accident.

It is possible for a fuel assembly to be mis-located adjacent to a storage rack in the northwest (area near the opening to the fuel transfer canal) and southeast (area near the opening to the cask loading pool) corners of the spent fuel storage pool. The worst case postulated accidents are: (1) in the southeast corner of the MZTR configuration, a fresh fuel assembly could be dropped and come to rest in the corner made up by a fresh assembly to the north and a Region 2 assembly to the west and (2) in the northwest corner of the checkerboard configuration, a fresh fuel assembly could be mis-located in a corner with fresh assemblies on two sides.

The k_{eff} values for these two cases are very similar, and exceed the limit on reactivity in the absence of soluble boron. Soluble boron in the spent fuel pool water, for which credit is permitted under these accident conditions, would assure that the reactivity is maintained substantially less than the design limitation. These cases are less severe than the misplaced fresh fuel assembly accidents, and thus, are bounded by them.

9.1A.2.2.6 Benchmark Calculations

The methodologies for determining criticality safety have been verified by comparison with critical experiment data for configurations that impose a stringent test of the capability of the analytical methodologies. These benchmark calculations have been made on selected critical experiments, chosen, in so far as possible to bound the range of variables in fuel storage rack designs, including the Callaway high density racks.

9.1A.2.2.6.1 Summary

Two independent methods of analysis were used in performing the Callaway fuel storage rack criticality safety analyses. These two methods differ in cross section libraries and in the treatment of the cross sections. MCNP4a (Reference 17) is a continuous energy Monte Carlo code and KENO5a (Reference 18) uses group-dependent cross sections. For the KENO5a analyses reported here, the 238-group library was chosen, processed

through the NITAWL-II (Reference 18) program to create a working library and to account for resonance self-shielding in uranium-238 (Nordheim integral treatment). The 238 group library was chosen to avoid or minimize the errors (trends) that have been reported (e.g., References 19-21) for calculations with collapsed cross section sets. Small but observable trends (errors) have been reported for calculations with the 27-group and 44-group collapsed libraries. These errors are probably due to the use of a single collapsing spectrum when the spectrum should be different for the various cases analyzed, as evidenced by the spectrum indices.

In rack designs, the three most significant parameters affecting criticality are (1) the fuel enrichment, (2) the ^{10}B loading in the neutron absorber, and (3) the lattice spacing (or water-gap thickness if a flux-trap design is used). Other parameters, within the normal range of rack and fuel designs, have a smaller effect, but are also included in the analyses.

Table 9.1A-7 summarizes results of the benchmark calculations for all cases selected and analyzed, as referenced in the table. The effect of the major variables are discussed in subsequent sections below. It is important to note that there is obviously considerable overlap in parameters since it is not possible to vary a single parameter and maintain criticality; some other parameter or parameters must be concurrently varied to maintain criticality.

One possible way of representing the data is through a spectrum index that incorporates all of the variations in parameters. KENO5a computes and prints the "energy of the average lethargy causing fission" (EALF). In MCNP4a, by utilizing the tally option with the identical 238-group energy structure as in KENO5a, the number of fissions in each group may be collected and the EALF determined (post-processing).

Figures 9.1A-7 and 9.1A-8 show the calculated k_{eff} for the benchmark critical experiments as a function of the EALF for MCNP4a and KENO5a, respectively (UO_2 fuel only). The scatter in the data (even for comparatively minor variation in critical parameters) represents experimental error in performing the critical experiments within each laboratory, as well as between the various testing laboratories. A classical example of experimental error is the corrected enrichment in the PNL experiments, first as an addendum to the initial report and, secondly, by revised values in subsequent reports for the same fuel rods. The B&W critical experiments show a larger experimental error than the PNL criticals. This would be expected since the B&W criticals encompass a greater range of critical parameters than the PNL criticals.

Linear regression analysis of the data in Figures 9.1A-7 and 9.1A-8 show that there are no trends, as evidenced by very low values of the correlation coefficient (0.13 for MCNP4a and 0.21 for KENO5a). The total bias (systematic error, or mean of the

deviation from a k_{eff} of exactly 1.000) for the two methods of analysis are shown in the table below.

Calculational Bias of MCNP4a and KENO5a	
MCNP4a	0.0009±0.0011
KENO5a	0.0030±0.0012

The bias and standard error of the bias were derived directly from the calculated k_{eff} values in Table 9.1A-7 using the following equations, with the standard error multiplied by the one-sided K-Factor for 95% probability at the 95% confidence level from NBS Handbook 91 (Reference 34) (for the number of cases analyzed, the K-Factor is ~2.05 or slightly more than 2). These equations may be found in any standard text on statistics, for example, Reference 22 (or the MCNP4a manual) and is the same methodology used in MCNP4a and in KENO5a.

$$\bar{k} = \frac{1}{n}\sum_{i}^{n} k_i \qquad (1)$$

$$\sigma_{\bar{k}}^2 = \frac{\sum_{i=1}^{n} k_i^2 + -\left(\sum_{i=1}^{n} k_i\right)^2 / n}{n(n-1)} \qquad (2)$$

$$\text{Bias} = (1-\bar{k}) \pm K\sigma_{\bar{k}} \qquad (3)$$

where k_i are the calculated reactivities of n critical experiments; $\sigma_{\bar{k}}$ is the unbiased estimator of the standard deviation of the mean (also called the standard error of the bias (mean)); K is the one-sided multiplier for 95% probability at the 95% confidence level (NBS Handbook 91 (Reference 34)).

Formula (3) is based on the methodology of the National Bureau of Standards (now NIST) and is used to calculate the values presented in the Table above. The first portion of the equation, (1- $\bar{k}$), is the actual bias which is added to the MCNP4a and KENO5a results. The second term, $K\sigma_{\bar{k}}$, is the uncertainty or standard error associated with the bias. The K values used were obtained from the National Bureau of Standards Handbook 91 and are for one-sided statistical tolerance limits for 95% probability at the 95% confidence level. The actual K values for the 56 critical experiments evaluated with MCNP4a and the 53 critical experiments evaluated with KENO5a are 2.04 and 2.05, respectively.

The bias values are used to evaluate the maximum k_{eff} values for the rack designs. KENO5a has a slightly larger systematic error than MCNP4a, but both result in greater precision than published data (References 19-21) would indicate for collapsed cross section sets in KENO5a (SCALE) calculations.

9.1A.2.2.6.2 Effect of Enrichment

The benchmark critical experiments include those with enrichments ranging from 2.46 w/o to 5.74 w/o and therefore span the enrichment range for rack designs. Figures 9.1A-9 and 9.1A-10 show the calculated k_{eff} values (Table 9.1A-7) as a function of the fuel enrichment reported for the critical experiments. Linear regression analyses for these data confirms that there are no trends, as indicated by low values of the correlation coefficients (0.03 for MCNP4a and 0.38 for KENO5a). Thus, there are no corrections to the bias for the various enrichments.

As further confirmation of the absence of any trends with enrichment, a typical configuration was calculated with both MCNP4a and KENO5a for various enrichments. The cross-comparison of calculations with codes of comparable sophistication is suggested in Reg. Guide 3.41. Results of this comparison, shown in Table 9.1A-8 and Figure 9.1A-8, confirm no significant difference in the calculated values of k_{eff} for the two independent codes as evidenced by the 45° slope of the curve. Since it is very unlikely that two independent methods of analysis would be subject to the same error, this comparison is considered confirmation of the absence of an enrichment effect (trend) in the bias.

9.1A.2.2.6.3 Effect of ^{10}B Loading

Several laboratories have performed critical experiments with a variety of thin absorber panels similar to the Boral panels in the rack designs. Of these critical experiments, those performed by B&W are the most representative of the rack designs. PNL has also made some measurements with absorber plates, but with one exception (a flux-trap experiment), the reactivity worth of the absorbers in the PNL tests is very low and any significant errors that might exist in the treatment of strong thin absorbers could not be revealed.

Table 9.1A-9 lists the subset of experiments using thin neutron absorbers (from Table 9.1A-7) and shows the reactivity worth (Δk) of the absorber. The reactivity worth of the absorber panels was determined by repeating the calculation with the absorber analytically removed and calculating the incremental (Δk) change in reactivity due to the absorber.

No trends with reactivity worth of the absorber are evident, although based on the calculations shown in Table 9.1A-9, some of the B&W critical experiments seem to have unusually large experimental errors. B&W made an effort to report some of their experimental errors. Other laboratories did not evaluate their experimental errors.

To further confirm the absence of a significant trend with ^{10}B concentration in the absorber, a cross-comparison was made with MCNP4a and KENO5a (as suggested in Reg. Guide 3.41). Results are shown in Figure 9.1A-9 and Table 9.1A-10 for a typical geometry. These data substantiate the absence of any error (trend) in either of the two codes for the conditions analyzed (data points fall on a 45° line, within an expected 95% probability limit).

9.1A.2.2.6.4 Miscellaneous and Minor Parameters

9.1A.2.2.6.4.1 Reflector Material and Spacings

PNL has performed a number of critical experiments with thick steel and lead reflectors. Analysis of these critical experiments are listed in Table 9.1A-11 (subset of data in Table 9.1A-7). There appears to be a small tendency toward overprediction of k_{eff} at the lower spacing, although there are an insufficient number of data points in each series to allow a quantitative determination of any trends. The tendency toward overprediction at close spacing means that the rack calculations may be slightly more conservative than otherwise.

9.1A.2.2.6.4.2 Fuel Pellet Diameter and Lattice Pitch

The critical experiments selected for analysis cover a range of fuel pellet diameters from 0.311 to 0.444 inches, and lattice spacings from 0.476 to 1.00 inches. In the rack designs, the fuel pellet diameters range from 0.303 to 0.3805 inches O.D. (0.496 to 0.580 inch lattice spacing) for PWR fuel and from 0.3224 to 0.494 inches O.D. (0.488 to 0.740 inch lattice spacing) for BWR fuel. Thus, the critical experiments analyzed provide a reasonable representation of power reactor fuel. Based on the data in Table 9.1A-7, there does not appear to be any observable trend with either fuel pellet diameter or lattice pitch, at least over the range of the critical experiments applicable to rack designs.

9.1A.2.2.6.4.3 Soluble Boron Concentration Effects

Various soluble boron concentrations were used in the B&W series of critical experiments and in one PNL experiment, with boron concentrations ranging up to 2550 ppm. Results of MCNP4a (and one KENO5a) calculations are shown in Table 9.1A-12. Analyses of the very high boron concentration experiments (>1300 ppm) show a tendency to slightly overpredict reactivity for the three experiments exceeding 1300 ppm. In turn, this would suggest that the evaluation of the racks with higher soluble boron concentrations could be slightly conservative.

9.1A.2.2.6.5 MOX Fuel

The number of critical experiments with PuO_2 bearing fuel (MOX) is more limited than for UO_2 fuel. However, a number of MOX critical experiments have been analyzed and the results are shown in Table 9.1A-13. Results of these analyses are generally above a k_{eff}

of 1.00, indicating that when Pu is present, both MCNP4a and KENO5a overpredict the reactivity. This may indicate that calculation for MOX fuel will be expected to be conservative, especially with MCNP4a. It may be noted that for the larger lattice spacings, the KENO5a calculated reactivities are below 1.00, suggesting that a small trend may exist with KENO5a. It is also possible that the overprediction in k_{eff} for both codes may be due to a small inadequacy in the determination of the Pu-241 decay and Am-241 growth. This possibility is supported by the consistency in calculated k_{eff} over a wide range of the spectral index (energy of the average lethargy causing fission).

9.1A.3 Thermal and Hydraulic Analyses

The Callaway reracked fuel storage pool (spent fuel pool and cask loading pool with fuel storage racks installed) and the Spent Fuel Pool Cooling and Cleanup System (SFPCCS) comply with the provisions of Section III of the USNRC "OT Position Paper for Review and Acceptance of Spent Fuel Storage and Handling Applications", (April 14, 1978). The methods, models, analyses, and numerical results are summarized below.

The thermal-hydraulic qualification analyses for the rack arrays fall into the following categories:

i Evaluation of the maximum decay heat load limit as a function of the bulk temperature limit for the postulated discharge scenario.

ii Evaluation of the postulated loss-of-forced cooling scenarios to establish that pool boiling will not occur.

iii Determination of the maximum temperature difference between the pool local temperature and the bulk pool temperature at the instant when the bulk temperature reaches its maximum value.

iv Evaluation of the maximum temperature difference between the fuel rod cladding temperature and the local pool water temperature to establish that nucleate boiling at any location around the fuel is not possible with forced cooling available.

Because the thermal and hydraulic analyses bound both the Callaway and Wolf Creek fuel storage pools, the pool water volume is conservatively based on the minimum east-west and north-south dimensions of the two pools. This conservatism results in a lower bound thermal inertia and outer periphery downcomer dimension in the thermal-hydraulic calculations.

SFPCCS at Callaway is described in Section 9.1.3. The fuel pool cooling system consists of two 100% capacity cooling trains for the removal of decay heat generated by irradiated fuel stored in the fuel storage pool. The decay heat generated by the stored fuel in the pool is transferred from the fuel pool cooling system through the fuel pool cooling heat exchangers. Normal makeup water to the spent fuel pool is supplied by the

reactor makeup water system. An alternate source of makeup water is the RWST via the fuel pool cleanup pumps. Emergency makeup water is supplied from the Essential Service Water system. Boron addition to the spent fuel pool is normally accomplished by supplying borated water from the boric acid tanks via the boric acid blending tee. Boron may also be added by using the RWST as the source of makeup water to the spent fuel pool. Isolation of non-safety related portions of the SFPCCS is a manual action.

The fuel pool cleanup system provides the capability for purification of the water in the spent fuel pool, the cask loading pool, the transfer canal, the refueling pool, and the RWST. The cleanup system is an essential adjunct to the SFPCCS system to maintain clarity and water chemistry control in the spent fuel pool.

Consistent with the current plant practice, two discharge scenarios are postulated when considering fuel storage pool cooling:

i partial core offload

ii full-core offload

In lieu of prescribing a batch size and cooling period for the partial core offload, the maximum pool heat load is determined for a scenario of only one cooling train operating and a limit on the steady state bulk pool temperature of 140°F.

Similarly, the full core offload scenario is required to be executed so that the maximum pool heat load will not allow for bulk pool boiling at the end of a postulated 2 hour loss of forced cooling transient which occurs immediately after the full core offload. More specifically, the bulk water temperature is sought to be limited to 207°F (which includes 5°F of margin) after two hours of pool heat-up in the absence of all forced cooling paths.

Evaluation of these two scenarios provides maximum flexibility in batch sizes and cooling periods prior to offload into the pool. In both scenarios, the component cooling water (CCW), used to remove heat from the spent fuel cooler, is assumed to be at its maximum design temperature. During the partial core offload scenario CCW flow is assumed to be at its nominal rate. During Full Core Offload conditions CCW flow is assumed to be at its design basis flow rate. With the thermal effectiveness of the spent fuel pool cooler thus fixed, the requirement of the ceiling on the bulk pool temperature essentially translates into a limit on the total heat generation rate in the pool.

Finally an evaluation is performed for a loss of cooling accident occurring some time after restart. This evaluation considers a four hour long loss of forced cooling in the SFPCCS followed by a twenty hour long period with cooling provided at one-half the normal coolant flow rate. Under this scenario, the spent fuel pool does not reach the bulk boiling temperature during the 24hour period. For this evaluation, the component cooling water to the heat exchanger is assumed to be at an elevated temperature and reduced flow rate.

9.1A.3.1 Decay Heat Load Limit

The heat load imposed on the pool is from the decay heat generated by fuel assemblies discharged into the pool. The primary safety function of the SFPCCS is to adequately transport this heat load to the CCW system and thereby maintain the bulk pool temperature within specified limits. Compliance with the limiting heat load will be ensured through adjustments to the cooling system performance and/or adjustments to the fuel offload rate. Commonly used decay heat calculation methods based upon ASB 9-2, ANS 5.1, or ORIGEN2 are used to provide conservative estimates of decay heat values for specific fuel pool inventories.

9.1A.3.1.1 Decay Heat Load Calculations and Conservatisms

The following conservatisms are applied in the decay heat load limit calculations.

- SFPCCS heat exchanger thermal performance is based on the design maximum fouling and plugging level. This will conservatively minimize the heat rejection capability of the SFPCCS.

- Thermal inertia induced transient effects resulting in a lag in bulk pool temperature response are neglected. This conservatively lowers the calculated decay heat load limit by forcing the peak decay heat load to coincide with the peak pool temperature.

- In calculating the spent fuel pool evaporation heat losses, the building housing the fuel storage pool is assumed to have a conservative ambient air temperature of 110°F and 100% relative humidity. This minimizes the evaporative heat loss component, maximizing the heat duty burden on the pool cooling system.

The mathematical formulation can be explained with reference to the simplified heat exchanger alignment of Figure 9.1A-10. Referring to the spent fuel pool cooling system, the governing differential equation can be written by utilizing conservation of energy as:

$$C\frac{dT}{d\tau} = Q(\tau) - Q_{HX}(T) - Q_{EV}(T)$$

where:

C = Pool thermal capacity, Btu/°F

T = Pool bulk temperature, °F

τ = Time after reactor shutdown, hr

$Q(\tau)$ = Time varying decay heat generation rate, Btu/hr

$Q_{HX}(T)$ = Temperature dependent SFPCCS heat rejection rate, Btu/hr

Q_{EV} (T) = Temperature dependent evaporative heat loss, Btu/hr

Subject to the second of the conservatisms listed above, this differential relationship can be reduced to the following algebraic relationship:

$$0 = Q_{limit} - Q_{HX}(T_{limit}) - Q_{EV}(T_{limit})$$

where:

T_{limit} is the maximum bulk pool temperature limit, °F

Q_{limit} is the decay heat load limit, Btu/hr

$Q_{HX}(T)$ is a function of the bulk pool temperature and the coolant water flow rate and temperature, and can be written in terms of the temperature effectiveness (p) as follows:

$$Q_{HX}(T) = W_t C_t p(T - t_i)$$

where:

W_t = Coolant water flow rate, lb/hr

C_t = Coolant water specific heat capacity, Btu/(lb x °F)

p = SFPCCS heat exchanger temperature effectiveness

T = Bulk pool water temperature, °F

t_i = Coolant water inlet temperature, °F

The temperature effectiveness, a measure of the heat transfer efficiency of the SFPCCS heat exchangers, is defined as:

$$p = \frac{t_o - t_i}{T - t_i}$$

where to is the coolant outlet temperature (°F) and all other terms are as defined above.

$Q_{EV}(T)$ is a nonlinear function of the pool temperature and ambient temperature. Q_{EV} contains the heat evaporation losses from the pool surface, natural convection and thermal radiation from the pool surface, and heat conduction through the pool walls and

slab. Experiments show that the heat conduction takes only about 4% of the total heat loss Reference 35.

The evaporation heat loss and natural convection heat loss can be expressed as Reference 36:

$$Q_{EV}(T) = hA(T - t_a) + \varepsilon\sigma A(T^4 - t_a^4) + \alpha A(P_w - P_a)$$

where:

h = Natural convection heat transfer coefficient, Btu/(hr xxft^2 x °F)

A = Pool surface area, ft^2

t_a = Ambient pool building temperature, °F

ε = Emissivity of pool water

σ = Stephan-Boltzmann constant

α = Evaporation rate constant, Btu/(hr x ft^2 x psi)

P_w = Vapor pressure of water at pool temperature, psi

P_a = Vapor pressure of water at ambient temperature, psi

The algebraic heat balance equation is solved for the decay heat load limit by rearranging the equation given above and substituting the maximum temperature limit for pool water temperature (T). The major input values for this analysis are summarized in Table 9.1A-14.

9.1A.3.2 Margin Against Boiling

To ensure that the pool bulk temperature will remain less than 207°F (i.e., adequate margin against boiling) compliance is required under the following conditions: (1) all forced cooling paths are lost following a full core offload and cooling is not restored for two hours, and (2) a loss of coolant accident occurs after restart and partial cooling is restored after 4 hours. The SFPCCS system has two independent trains, both of which are seismically qualified and safety-related, so a complete loss of forced cooling is not possible under single failure criteria. Regardless of this fact, these evaluations are performed for postulated non-mechanistic loss of forced cooling accidents.

9.1A.3.2.1 Heat-up Calculations and Conservatisms

The following conservatisms are applied in the heat-up calculations.

- The decay heat load and bulk pool temperature are assumed to be the calculated decay heat load limit and corresponding maximum pool temperature limit. Maximizing the initial temperature and the decay heat load conservatively minimizes the time-to-boil.

- The LOCA scenario, with its four hour loss of cooling to the SFPCCS, is based on the decay heat load limit and corresponding peak temperature limit of the previously evaluated partial core discharge. These conditions would occur during an offload, and would therefore bound a post-restart condition.

- The transient reduction in decay heat over time is conservatively neglected. This maximizes the decay heat load at all points in time and minimizes the time-to-boil.

- Calculations verify that sufficient makeup water exists to prevent the pool water level from dropping, but no credit is taken for the reduced temperature of the makeup water. This assumes that makeup water is provided at the bulk pool temperature, conservatively minimizing the time-to-boil.

- In calculating the fuel storage pool evaporation heat losses, the building housing the fuel storage pool is assumed to have a conservative ambient air temperature of 110°F and 100% relative humidity. This conservatively minimizes the credit for evaporative heat loss.

The temperature rise of the water in the pool over any period of time is a direct function of the average net decay heat load during that period. Therefore, maximizing the decay heat load will maximize the pool temperature increase rate and minimize the corresponding time-to-boil. As a transient decay heat load would necessitate a reduced average net heat load, the steady-state assumptions are conservative.

The governing enthalpy balance equation for this condition, subject to these conservative assumptions, is written as:

$$C\frac{dT}{d\tau} = Q_{limit} - Q_{EV}(T)$$

where τ is the time after cooling is lost (hr) and all other terms are the same as defined in Section 9.1A.3.1.

This differential equation is solved using a numerical solution technique to obtain the bulk pool temperature as a function of time. The major input values for the analysis are summarized in Table 9.1A-15.

9.1A.3.2.2 Time-to-Boil

When the SFPCCS forced pool cooling becomes unavailable, the pool water will begin to rise in temperature and eventually will reach the normal bulk boiling temperature of 212°F. In order to maintain some margin to this boiling condition, the analyses are performed with the acceptance criterion of a bulk pool temperature that is ≤ 207°F. The time to reach the boiling point is the shortest when the loss of forced cooling occurs at the point in time when the pool bulk temperature is at its maximum calculated value. Although the probability of the loss-of-cooling event coinciding at the instant when the pool water has reached its peak value is extremely remote, the calculations were performed under this extremely unlikely scenario.

Analysis shows that, for postulated full-core discharge, and a maximum bulk temperature of 207°F after two hours without cooling, the maximum allowable decay heat load is 63.41 MBtu/hr. The steady-state SFP temperature at this heat load would be 169.68°F.

For the loss of coolant accident scenario, the bulk temperature after four hours without cooling would be 172.1°F. Once partial cooling is reestablished, the steady-state temperature would be less than 175°F, thereby precluding the possibility of boiling even with continued reduced cooling capacity.

9.1A.3.3 Local Pool Water Temperature

A single conservative evaluation for a bounding amalgam of conditions was performed to evaluate the local pool water temperature. The result of the single evaluation is a bounding temperature difference between the maximum local water temperature and the bulk pool temperature.

In order to determine an upper bound on the maximum local water temperature, a series of conservative assumptions are made. The most important of these assumptions are:

- With a full core discharged into the racks farthest from the coolant water inlet, the remaining cells in the spent fuel pool are postulated to be occupied with previously discharged fuel.

- The hottest assemblies, located together in the pool, are assumed to be located in "pedestal" cells of the racks. These cells have a reduced water entrance area, caused by the pedestal blocking the baseplate hole, and a correspondingly increased hydraulic resistance.

- The coolant water inlet temperature, and therefore the bulk pool temperature, is minimized to conservatively maximize the fluid viscosity.

This assumption will maximize the head losses for water flowing through the fuel racks and fuel assemblies.

- No downcomer flow is assumed to exist between the rack modules.

- All rack cells are conservatively assumed to be 50% blocked at the cell outlet to account for drop accidents resulting in damage to the upper end of the cells. This blocked cell portion is conservative, since structural evaluations have shown that only about 20% of the cell is blocked subsequent to the impact of dropped objects.

- Westinghouse 17x17 STD assembly, which is most resistive to axial fluid flow, is assumed to populate the entire storage region. Thus, the hydraulic resistance to heat transfer is maximized.

9.1A.3.3.1 Local Temperature Evaluation Methodology

The inlet piping which returns cooled pool water from the SFPCCS terminates above the level of the fuel racks. To demonstrate adequate cooling of hot fuel in the pool, it is necessary to rigorously quantify the velocity field in the pool created by the interaction of buoyancy driven flows and water injection/egress. A Computational Fluid Dynamics (CFD) analysis for this demonstration is required. The objective of this study is to demonstrate that the principal thermal-hydraulic criteria of ensuring local subcooled conditions in the pool is met for all postulated fuel discharge/cooling alignment scenarios. The local thermal-hydraulic analysis is performed such that partial cell blockage and slight fuel assembly variations are bounded. An outline of the CFD approach is described in the following.

There are several significant geometric and thermal-hydraulic features of the fuel storage pool which must be considered for a rigorous CFD analysis. From a fluid flow modeling standpoint, there are two regions to be considered. One region is the bulk pool/cask loading pool region where the classical Navier-Stokes equations are solved with turbulence effects included. The other region is the heat generating fuel assemblies located in the spent fuel racks located near the bottom of the fuel storage pool. In this region, water flow is directed vertically upwards due to buoyancy forces through relatively small flow channels formed by the Westinghouse 17x17 fuel assembly rod arrays in each rack cell. This situation shall be modeled as a porous solid region in which fluid flow is governed by the classical Darcy's Law:

$$\frac{\partial P}{\partial X_i} = -\frac{\mu}{K(i)}V_i - C\rho V\frac{V_i}{2}$$

where $\partial p/\partial X_i$ is the pressure gradient, K(i), V_i and C are the corresponding permeability, velocity and inertial resistance parameters and μ is the fluid viscosity. The permeability and inertial resistance parameters for the rack cells loaded with Westinghouse 17x17

fuel were determined based on the friction factor correlations for the laminar flow conditions typically encountered due to the low buoyancy induced velocities and the small size of the flow channels.

The fuel storage pool geometry required an adequate portrayal of large scale and small scale features, spatially distributed heat sources in the fuel storage racks and water inlet/ outlet configuration. Relatively cooler bulk pool water normally flows down between the fuel rack outline and pool wall liner clearance known as the downcomer. Near the bottom of the racks, the flow turns from a vertical to horizontal direction into the bottom plenum supplying cooling water to the rack cells. Heated water issuing out of the top of the racks mixes with the bulk pool water. An adequate modeling of these features on the CFD program involves meshing the large scale bulk pool region and small scale downcomer and bottom plenum regions with sufficient number of computational cells to capture the bulk and local features of the flow field.

The distributed heat sources in the spent fuel pool racks are modeled by identifying distinct heat generation zones considering full-core discharge, bounding peak effects, and presence of background decay heat from old discharges. Three heat generating zones were modeled. The first consists of background fuel from previous discharges, the remaining two zones consist of fuel from a bounding full-core-discharge scenario. The two full core discharge zones are differentiated by one zone with higher than average decay heat generation and the other with less than average decay heat generation. The background decay heat load is determined such that the total decay heat load in the pool is equal to the calculated decay heat load limit. This is a conservative model, since all of the fuel with higher than average decay heat is placed in a contiguous area. A uniformly distributed heat generation rate was applied throughout each distinct zone.

The CFD analysis was performed on the industry standard FLUENT (Reference 40) fluid flow and heat transfer modeling program. The FLUENT code enabled buoyancy flow and turbulence effects to be included in the CFD analysis. Turbulence effects are modeled by relating time-varying "Reynolds's Stresses" to the mean bulk flow quantities with the following turbulence modeling options:

(i) k-ε Model

(ii) RNG k-ε Model

(iii) Reynolds Stress Model

The k-ε Model is considered most appropriate for the twin site CFD analysis. The k-ε turbulence model is a time-tested, general purpose turbulence model. This model has been demonstrated to give good results for the majority of turbulent fluid flow phenomena. The Renormalization Group (RNG) and Reynolds Stress models are more advanced models that were developed for situations where the k-ε Model does not provide acceptable results, such as high viscosity flow and supersonic shock. The flow regime in the bulk fluid region is such that the k-ε Model will provide acceptable results.

Rigorous modeling of fluid flow problems requires a solution to the classical Navier-Stokes equations of fluid motion (Reference 37). The governing equations (in modified form for turbulent flows with buoyancy effects included) are written as:

$$\frac{\partial \rho_o u_i}{\partial t} + \frac{\partial \rho_o \langle u_i' u_j' \rangle}{\partial x_i} = \frac{\partial}{\partial x_i}\left[\mu\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right)\right] - \frac{\partial p}{\partial x_i} - \rho_o \beta (T - T_o) g_i + \frac{\partial \rho_o \langle u_i' u_j' \rangle}{\partial x_j}$$

where u_i are the three time-averaged velocity components. $\rho \langle u_i' u_j' \rangle$ are time-averaged Reynolds stresses derived from the turbulence induced fluctuating velocity components u_i', ρ_o is the fluid density at temperature T_o, β is the coefficient of thermal expansion, μ is the fluid viscosity, g_i are the components of gravitational acceleration and x_j are the Cartesian coordinate directions. The Reynolds stress tensor is expressed in terms of the mean flow quantities by defining a turbulent viscosity μt and a turbulent velocity scale $k^{1/2}$ as shown below (Reference 38):

$$\rho \langle u_i' u_j' \rangle = 2/3 \rho k \delta_{ij} - \mu_t \left[\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right]$$

The procedure to obtain the turbulent viscosity and velocity length scales involves a solution of two additional transport equations for kinetic energy (k) and rate of energy dissipation (ε). This methodology is known as the k-ε model for turbulent flows as described by Launder and Spalding (Reference 39).

Some of the major input values for this analysis are summarized in Table 9.1A-16. An isometric view of the assembled CFD model is presented in Figure 9.1A-11.

9.1A.3.3.2 Local Water and Fuel Cladding Temperatures

Consistent with the approach to make conservative assessments of temperature, the local water temperature calculations are performed for a pool with decay heat generation equal to the maximum calculated decay heat load limit. Thus, the local water temperature evaluation is a calculation of the temperature increment over the theoretical spatially uniform value due to local hot spots (due to the presence of a highly heat emissive fuel bundle).

The CFD study has analyzed a single bounding local thermal-hydraulic scenario. In this scenario, a bounding full-core discharge is considered in which the 193 assemblies are located in the pool, farthest from the cooled water inlet, while the balance of the rack cells are postulated to be occupied by fuel from old discharges.

In this analysis, the difference between the peak local temperature and the coincident bulk pool temperature was conservatively calculated to be 64.6°F.

The peak fuel cladding superheat is determined for the hottest cell location in the pool as obtained from the CFD model for the twin site pools. The maximum temperature difference between the fuel cladding and the local water (ΔTc) is calculated to be less than 67.4°F. Applying this calculated cladding ΔTc, along with the maximum temperature difference between the local water temperature and the bulk pool temperature, to the bulk maximum normal operating pool temperature of 170°F yields a conservatively bounding 234.6°F maximum local water temperature and a conservatively bounding 302°F peak cladding temperature. The maximum local water temperature is lower than the 239°F local boiling temperature on top of the racks, thereby precluding nucleate boiling in the subchannel. The heat fluxes are too low to support a departure from nucleate boiling (DNB) condition. Thus, nucleate and departure from nucleate boiling do not occur anywhere within the Callaway fuel storage pool.

9.1A.3.4 Fuel Rod Cladding Temperature

The temperature of the fuel rod cladding is performed for a single, bounding scenario. The maximum fuel cladding superheat above the local water temperature is calculated.

The maximum specific power of a fuel array q_A can be given by:

$$q_A = q\ F_{xy}$$

where:

F_{xy} = Radial peaking factor

q = Average fuel assembly specific power, Btu/hr

The peaking factors are given in Table 9.1A.-16. The maximum temperature rise of pool water in the most disadvantageously placed fuel assembly, defined as the one which is subject to the highest local pool water temperature, was computed for all loading cases. Having determined the maximum local water temperature in the pool, it is now possible to determine the maximum fuel cladding temperature. A fuel rod can produce F_z times the average heat emission rate over a small length, where F_z is the axial rod peaking factor. The axial heat distribution in a rod is generally a maximum in the central region, and tapers off at its two extremities. Thus, peak cladding heat flux over an infinitesimal area is given by the equation:

$$q_c = \frac{qF_{xy}F_z}{A_c}$$

where A_c is the total cladding external heat transfer area in the active fuel length region.

Within each fuel assembly sub-channel, water is continuously heated by the cladding as it moves axially upwards from bottom to top under laminar flow conditions. Rohsenow and Hartnett (Reference 41) report a Nusselt-number based heat transfer correlation for laminar flow in a heated channel. The film temperature driving force (ΔT_f) at the peak cladding flux location is calculated as follows:

$$h_f \frac{D_h}{K_W} = Nu$$

$$\Delta T_f = \frac{q_c}{h_f}$$

where, h_f is the water side film heat transfer coefficient, D_h is sub-channel hydraulic diameter, K_w is water thermal conductivity and Nu is Nusselt number for laminar flow heat transfer.

In order to introduce some additional conservatism in the analysis, we assume that the fuel cladding has a crud deposit resistance R_c (equal to 1.67×10^{-4} ft^2-hr-°F/Btu), which covers the entire surface. Thus, including the temperature drop across the crud resistance, the cladding to water local temperature difference (ΔT_c) is given by:

$$\Delta T_c = \Delta T_f + R_c q_c$$

9.1A.3.5 Decay Heat Load Limits

The calculated decay heat load limit is summarized in Table 9.1A-17. Because all transient effects were excluded from the evaluations, this decay heat load corresponds to the invariant heat load which results in a steady-state bulk pool temperature which will not exceed the temperature limit for either the partial core or full core offload scenario.

This calculated decay heat load limit is not based on any specific discharge conditions, but is a mathematically derived quantity. Any conservative decay heat calculation used to determine the operational limits (i.e. in-core hold time requirement) necessary to avoid exceeding this decay heat load provides conservative operational limits. The operational limits are determined based on the decay heat load limit in Table 9.1A-17. Based on this limit, the fuel storage pool cooling system will remain in compliance.

9.1A.4 Structural and Seismic Considerations

The structural adequacy of the high density spent fuel racks are considered under all loadings postulated for normal, seismic, and accident conditions. The spent fuel storage racks must remain fully functional during and after a seismic disturbance. The seismic adequacy is demonstrated in response to both a Safe Shutdown Earthquake (SSE) and

the Operational Design Basis Earthquake (OBE). The analyses undertaken to confirm the structural integrity of the racks are performed in compliance with the USNRC Standard Review Plan (Reference 42) and the OT Position Paper (Reference 43).

The response of a free-standing rack module to seismic inputs is highly nonlinear and involves a complex combination of motions (sliding, rocking, twisting, and turning), resulting in impacts and friction effects. Some unique attributes of rack dynamic behavior include a large fraction of the total structural mass in a confined rattling motion, friction support of rack pedestals against lateral motion, and large fluid coupling effects due to deep submergence and independent motion of closely spaced adjacent structures. Whole Pool Multi-Rack (WPMR) analysis simulates the dynamic behavior of the storage rack structures. The walls separating the Spent Fuel Pool and the Cask Loading Pool allow rack configurations to be dynamically analyzed as two separate WPMR models.

9.1A.4.1 Analysis Methodology

An accurate simulation is obtained by direct integration of the nonlinear equations of motion with three pool slab acceleration time-histories applied as the forcing functions acting simultaneously. Reliable assessment of the stress field and kinematic behavior of the rack modules incorporates key attributes of the actual structure in a conservative dynamic model. The model must have the capability to execute the concurrent motion forms compatible with the free-standing installation of the modules.

Calculations must incorporate momentum transfers due to the rattling of fuel assemblies inside storage cells; the lift-off and subsequent impact of support pedestals with the pool liner (or bearing pad); and quantification of fluid coupling due to water mass in the interstitial spaces around rack modules. In short, there are a large number of parameters with potential influence on the rack kinematics. The comprehensive structural evaluation must deal with all of these without sacrificing conservatism.

The model must be capable of effecting momentum transfers which occur due to rattling of fuel assemblies inside storage cells and the capability to simulate lift-off and subsequent impact of support pedestals with the pool liner (or bearing pad). The contribution of the water mass in the interstitial spaces around the rack modules and within the storage cells must be modeled in an accurate manner. During dynamic rack motion, hydraulic energy is either drawn from or added to the moving rack, modifying its submerged motion in a significant manner. Therefore, the dynamics of one rack affects the motion of all others in the pool.

The 3-D rack model dynamic simulation, involving one or more spent fuel racks, handles the following array of variables:

Interface Coefficient of Friction Parametric runs are made with upper bound and lower bound values of the coefficient of friction. The limiting values are based on experimental data which have been found to be bounded by the values 0.2 and 0.8. Simulations are

also performed with the array of pedestals having randomly chosen coefficients of friction in a Gaussian distribution with a mean of 0.5 and lower and upper limits of 0.2 and 0.8, respectively. In the fuel rack simulations, the Coulomb friction interface between rack support pedestal and liner is simulated by piecewise linear (friction) elements. These elements function only when the pedestal is physically in contact with the pool liner.

Rack Beam Behavior Rack elasticity, relative to the rack base, is included in the model by introducing linear springs to represent the elastic bending action, twisting, and extensions.

Impact Phenomena Compression-only gap elements are used to provide for opening and closing of interfaces such as the pedestal-to-bearing pad interface, and the fuel assembly-to-cell wall interface. These interface gaps are modeled using nonlinear spring elements. The term "nonlinear spring" is a generic term used to denote the mathematical representation of the condition where a restoring force is not linearly proportional to displacement.

Fuel Loading Scenarios The fuel assemblies are conservatively assumed to rattle in unison which obviously exaggerates the contribution of impact against the cell wall.

Fluid Coupling The computer code DYNARACK (Reference 47) handles simultaneous simulation of all racks in the pool as a Whole Pool Multi-Rack 3-D analysis. The code has been utilized in numerous other plant rerack projects. The WPMR analyses have corroborated the accuracy of the single rack 3-D solutions in predicting the maximum structural stresses, and in improving predictions of rack kinematics.

For closely spaced racks, demonstration of kinematic compliance is verified by including all modules in one comprehensive simulation using a WPMR model. In WPMR analysis, all rack modules are modeled simultaneously and the coupling effect due to this multi-body motion is included in the analysis. Due to the superiority of this technique in predicting the dynamic behavior of closely spaced submerged storage racks, the Whole Pool Multi-Rack analysis methodology was used.

9.1A.4.1.1 Fuel Weights

For the dynamic rack simulations, the dry fuel weight is conservatively taken to be 1647 lbs. This is a higher fuel weight value to account for rod control cluster assemblies (RCCAs) being stored along with fuel assemblies. Therefore, the analyses conservatively consider an RCCA to be stored along with an assembly at every location.

9.1A.4.1.2 Synthetic Time-Histories

The synthetic time-histories in three orthogonal directions (N-S, E-W, and vertical) are generated in accordance with the provisions of SRP 3.7.1 (Reference 48). A preferred criterion for the synthetic time-histories in SRP 3.7.1 calls for both the response spectrum and the power spectral density corresponding to the generated acceleration

time-history to envelope their target (design basis) counterparts with only finite enveloping infractions. The time-histories for the pools have been generated to satisfy this preferred (and more rigorous) criterion. The seismic files also satisfy the requirements of statistical independence mandated by SRP 3.7.1.

Figures 9.1A-12 through 9.1A-16 provide plots of the time-history accelerograms which were generated over a 25 second duration for OBE and SSE events, respectively. These artificial time-histories are used in all non-linear dynamic simulations of the racks.

Results of the correlation function of the three time-histories are given in Table 9.1A-19. Absolute values of the correlation coefficients are shown to be less than 0.15, indicating the statistical independence of the three data sets.

9.1A.4.2 WPMR Methodology

The WPMR methodology incoporates both stress and displacement criteria. The following summarizes the sequence steps undertaken for model development:

a. Suitable 3-D dynamic models for a time-history analysis of the new maximum density racks are prepared. These models include the assemblage of all rack modules in each pool. Include all fluid coupling interactions and mechanical coupling appropriate to performing an accurate non-linear simulation. This 3-D simulation is referred to as a Whole Pool Multi-Rack model.

b. 3-D dynamic analyses are performed on various physical conditions (such as coefficient of friction and extent of cells containing fuel assemblies). Appropriate displacement and load outputs from the dynamic model for post-processing are archived..

c. A stress analysis of high stress areas for the limiting case of all the rack dynamic analyses is performed to demonstrate compliance with ASME Code Section III, Subsection NF limits on stress and displacement.

9.1A.4.2.1 Model Assumptions

The dynamic modeling of the rack structure considers all nonlinearities and parametric variations. The following assumptions are used in the Whole Pool Multi-Rack analysis of racks:

a. The fuel rack structure motion is captured by modeling the rack as a 12 degree-of-freedom structure. Movement of the rack cross-section at any height is described by six degrees-of-freedom of the rack base and six degrees-of-freedom at the rack top. In this manner, the response of the module, relative to the baseplate, is captured in the dynamic analyses once

suitable springs are introduced to couple the rack degrees-of°Freedom and simulate rack stiffness.

b. Rattling fuel assemblies within the rack are modeled by five lumped masses located at H, .75H, .5H, .25H, and at the rack base (H is the rack height measured above the baseplate). Each lumped fuel mass has two horizontal displacement degrees-of-freedom. Vertical motion of the fuel assembly mass is assumed equal to rack vertical motion at the baseplate level. The centroid of each fuel assembly mass can be located off-center, relative to the rack structure centroid at that level, to simulate a partially loaded rack.

c. Seismic motion of a fuel rack is characterized by random rattling of fuel assemblies in their individual storage locations. All fuel assemblies are assumed to move in-phase within a rack. This exaggerates computed dynamic loading on the rack structure and, therefore, yields conservative results.

d. Fluid coupling between rack and fuel assemblies, and between rack and wall, is simulated by appropriate inertial coupling in the system kinetic energy. These effects uses the methods (References 51 and 52) for rack/assembly coupling and for rack-to-rack coupling. The fluid coupling effect in its simplest form considers the proximate motion of two bodies under water, where one body vibrates adjacent to a second body, and both bodies are submerged in frictionless fluid. During a seismic event all racks in the pool are subject to the input excitation simultaneously. The WPMR model simulates 3-D motion of all rack modules simultaneously and encompasses interaction between every set of racks in the pool, i.e., the motion of one rack produces fluid forces on all other racks and on the pool walls.

e. Fluid damping and form drag are conservatively neglected.

f. Sloshing is found to be negligible at the top of the rack and is, therefore, neglected in the analysis of the rack.

g. Potential impacts between the cell walls of the new racks and the contained fuel assemblies are accounted for by appropriate compression-only gap elements between masses involved. The possible incidence of rack-to-wall or rack-to-rack impact is simulated by gap elements at the top and bottom of the rack in two horizontal directions. Bottom gap elements are located at the baseplate elevation. The initial gaps reflect the presence of baseplate extensions, and the rack stiffnesses are chosen to simulate local structural detail.

h. Pedestals are modeled by gap elements in the vertical direction and as "rigid links" for transferring horizontal stress. Each pedestal support is linked to the pool liner (or bearing pad) by two friction springs. The spring rate for the friction springs includes any lateral elasticity of the stub pedestals. Local pedestal vertical spring stiffness accounts for floor elasticity and for local rack elasticity just above the pedestal.

i. Rattling of fuel assemblies inside the storage locations causes the gap between fuel assemblies and cell wall to change from a maximum of twice the nominal gap to a theoretical zero gap. Fluid coupling coefficients are based on the nominal gap in order to provide a conservative measure of fluid resistance to gap closure.

j. The model for the rack is considered supported, at the base level, on four pedestals modeled as non-linear compression only gap spring elements and eight piecewise linear friction spring elements; these elements are properly located with respect to the centerline of the rack beam, and allow for arbitrary rocking and sliding motions.

9.1A.4.2.2 Stiffness Elements

Three element types are used in the rack models. Type 1 are linear elastic elements used to represent the beam-like behavior of the integrated rack cell matrix. Type 2 elements are the piece-wise linear friction springs used to develop the appropriate forces between the rack pedestals and the supporting bearing pads. Type 3 elements are non-linear gap elements which model gap closures and subsequent impact loadings (i.e., between fuel assemblies and the storage cell inner walls, and rack outer periphery spaces.

9.1A.4.2.3 Coefficients of Friction

Multiple simulations were performed to adjust the friction coefficient ascribed to the support pedestal/pool bearing pad interface. These friction coefficients are chosen consistent with the two bounding extremes from Rabinowicz's data (Reference 50). Simulations are also performed by imposing intermediate value friction coefficients developed by a random number generator with Gaussian normal distribution characteristics. The assigned values are then held constant during the entire WPMR simulation in order to obtain reproducible results, closer to realistic structural conditions.

9.1A.4.2.4 Governing Equations of Motion

Using the structural model discussed in the foregoing, equations of motion corresponding to each degree-of-freedom are obtained using Lagrange's Formulation (Reference 53). The system kinetic energy includes contributions from solid structures and from trapped and surrounding fluid. The final system of equations obtained have the matrix form:

$$[M]\left[\frac{d^2q}{dt^2}\right] = [Q] + [G]$$

where:

[M]	-	total mass matrix (including structural and fluid mass contributions). The size of this matrix will be 22n x22n for a WPMR analysis (n = number of racks in the model).
q	-	the nodal displacement vector relative to the pool slab displacement (the term with q indicates the second derivative with respect to time, i.e., acceleration)
[G]	-	a vector dependent on the given ground acceleration
[Q]	-	a vector dependent on the spring forces (linear and nonlinear) and the coupling between degrees-of-freedom

$$\left[\frac{d^2q}{dt^2}\right] = [M]^{-1}[Q] + [M]^{-1}[G]$$

This equation set is mass uncoupled, displacement coupled at each instant in time. The numerical solution uses a central difference scheme built into the computer program DYNARACK (Reference 47).

9.1A.4.3 Structural Evaluation of the Fuel Rack Design

There are two sets of criteria to be satisfied by the rack modules:

a. Kinematic Criteria

Per Reference (Reference 42), in order to be qualified as a physically stable structure it is necessary to demonstrate that an isolated rack in water would not overturn when an event of magnitude:

- 1.5 times the upset seismic loading condition is applied.
- 1.1 times the faulted seismic loading condition is applied.

b. Stress Limit Criteria

Stress limits must not be exceeded under the postulated load combinations provided herein.

9.1A.4.3.1 Stress Limit Evaluations

The stress limits that apply to the rack structure are derived from the ASME Code, Section III, Subsection NF (Reference 55). Parameters and terminology are in accordance with the ASME Code. Material properties are obtained from the ASME Code Appendices (Reference 56), and are listed in Table 9.1A-18. For convenience, the stress results are presented in dimensionless form. Dimensionless stress factors are defined as the ratio of the actual developed stress to the specified limiting value. The limiting value of each stress factor is 1.0, based on the allowable strengths for each level, for Levels A, B, and D. Stress factors reported are:

R_1 = Ratio of direct tensile or compressive stress on a net section to its allowable value (note pedestals only resist compression)

R_2 = Ratio of gross shear on a net section in the x-direction to its allowable value

R_3 = Ratio of maximum x-axis bending stress to its allowable value for the section

R_4 = Ratio of maximum y-axis bending stress to its allowable value for the section

R_5 = Combined flexure and compressive factor (as defined in the foregoing)

R_6 = Combined flexure and tension (or compression) factor (as defined in the foregoing)

R_7 = Ratio of gross shear on a net section in the y-direction to its allowable value

9.1A.4.3.2 Loads and Loading Combinations for Fuel Storage Racks

The applicable loads and their combinations which must be considered in the seismic analysis of rack modules is excerpted from Refs. (Reference 43) and (Reference 57). The load combinations considered are identified below:

Loading Combination	Service Level
$D + L$ $D + L + T_o$ $D + L + T_o + E$	Level A
$D + L + T_a + E$ $D + L + T_o + P_f$	Level B

Loading Combination	Service Level
D + L + T_a + E'	Level D
D + L + T_o + F_d	The functional capability of the fuel racks must be demonstrated.

Where:

D	=	Dead weight-induced loads (including fuel assembly weight)
L	=	Live Load (not applicable for the fuel rack, since there are no moving objects in the rack load path)
P_f	=	Upward force on the racks caused by postulated stuck fuel assembly
F_d	=	Impact force from accidental drop of the heaviest load from the maximum possible height.
E	=	Operating Basis Earthquake (OBE)
E'	=	Safe Shutdown Earthquake (SSE)
T_o	=	Differential temperature induced loads (normal operating or shutdown condition based on the most critical transient or steady state condition)
T_a	=	ifferential temperature induced loads (the highest temperature associated with the postulated abnormal design conditions)

T_a and T_o produce local thermal stresses. The worst thermal stress field in a fuel rack is obtained when an isolated storage location has a fuel assembly generating heat at maximum postulated rate and surrounding storage locations contain no fuel. Heated water makes unobstructed contact with the inside of the storage walls, thereby producing maximum possible temperature difference between adjacent cells. Secondary stresses produced are limited to the body of the rack; that is, support pedestals do not experience secondary (thermal) stresses.

9.1A.4.3.3 Parametric Simulations

The table below presents a complete listing of the parametric simulations performed.

Consideration of the parameters described above resulted in the following 19 runs.

Run	Pool	COF	Event
1	SFP	0.8	SSE
2	SFP	0.2	SSE
3	SFP	Random	SSE
4	SFP	0.8	OBE
5	SFP	0.2	OBE
6	SFP	Random	OBE
7	Cask Loading Pool	0.8	SSE
8	Cask Loading Pool	0.2	SSE
9	Cask Loading Pool	Random	SSE
10	Cask Loading Pool	0.8	OBE
11	Cask Loading Pool	0.2	OBE
12	Cask Loading Pool	Random	OBE
13	SFP (half full)	0.8	SSE
14	SFP (half full)	0.2	SSE
15	SFP (half full)	Random	SSE
16	Single Rack - Overturning Check	0.8	OBE x 1.5
17	Single Rack - Overturning Check	0.8	SSE x 1.1

9.1A.4.3.4 Time History Simulation Results

The results from the DYNARACK runs are presented by extracting the worst case values from the parameters of interest; namely displacements, support pedestal forces, impact loads, and stress factors.

9.1A.4.3.4.1 Rack Displacements

Selected rack to wall and rack to rack gaps were evaluated over the entire duration of the 0.8 COF SSE simulation (run 1) for three selected locations around the perimeter of SFP

rack no. 14. This simulation produced the largest displacement (0.677") of any rack in the SFP. Rack 2 in the Cask Loading Pool (run 9) experiences a larger displacement of (1.274"). However, in the Cask Loading Pool the rack to wall gaps are larger. Therefore, SFP Rack 14 is chosen for displacement plotting because the displacements are of greater significance for the SFP simulations.

Rack to rack impacts may be identified when rack gaps are momentarily reduced to a value of zero or less. Rack to wall impacts did not occur under any of the simulations.

A tabulated summary of the maximum displacement for each simulation is provided below with the location/direction terms defined as follows:

uxt, uyt = displacement of top corner of rack, relative to the slab, in the North-South and East-West directions, respectively. The maximum displacements for every simulation, including the single rack tipover analyses, occurred at the top of the racks shown in the last table column.

Simulations 16 and 17 were performed to evaluate the potential for overturning of a rack to account for the unlikely possibility of a seismic event occurring during the installation process. The heaviest racks with the narrowest pedestal stance are chosen for these simulations, since these racks are expected to produce the greatest displacements during seismic events. All of these simulations were performed with half loaded racks to further increase displacements. The largest displacement is less than 0.5 inches and is not a tipover concern.

The following maximum rack displacements (in inches) are obtained for each of the runs:

Pool	Event	Run	COF	Maximum Displacement (inches)	Location/ Direction	Rack
Spent Fuel Pool	SSE	1	0.8	0.677	uxt	14
	SSE	2	0.2	0.428	uyt	7
	SSE	3	Random	0.642	uxt	15
	OBE	4	0.8	0.341	uyt	1
	OBE	5	0.2	0.280	uyt	1
	OBE	6	Random	0.343	uyt	1
Cask Loading Pool	SSE	7	0.8	1.274	uyt	2

Pool	Event	Run	COF	Maximum Displacement (inches)	Location/ Direction	Rack
	SSE	8	0.2	0.720	uxt	1
	SSE	9	Random	0.965	uyt	3
	OBE	10	0.8	0.275	uxt	1
	OBE	11	0.2	0.275	uxt	1
	OBE	12	Random	0.275	uxt	1
Half full SFP	SSE	13	0.8	0.3921	uxt	6
	SSE	14	0.2	0.562	uyt	8
	SSE	15	Random	0.578	uyt	6
Tipover	OBE	16	0.8	0.288	-	-
Tipover	SSE	17	0.8	0.338	-	-

Note: All of the maximum displacements occurred at the tops of the storage racks, as expected from swaying, bending, and tipping behavior.

9.1A.4.3.4.2 Pedestal Vertical Forces

Pedestal number 1 for each rack is located in the northeast corner of the rack. Numbering increases counterclockwise around the periphery of each rack. The following bounding vertical pedestal forces (in kips) are obtained for each run:

Pool	Event	Run	COF	Maximum Pedestal Load (kips)	Rack	Ped.
Spent Fuel Pool	SSE	1	0.8	291	12	3
	SSE	2	0.2	235	3	2
	SSE	3	Random	267	1	4
	OBE	4	0.8	203	1	4
	OBE	5	0.2	188	1	2
	OBE	6	Random	204	1	4

Pool	Event	Run	COF	Maximum Pedestal Load (kips)	Rack	Ped.
Cask Loading Pool	SSE	7	0.8	197	3	3
	SSE	8	0.2	162	1	4
	SSE	9	Random	159	3	4
	OBE	10	0.8	103	1	1
	OBE	11	0.2	103	1	2
	OBE	12	Random	103	1	2
Half full SFP	SSE	13	0.8	211	6	4
	SSE	14	0.2	220	4	3
	SSE	15	Random	255	3	2

The highest pedestal load of 291,000 lbs occurs in run 1.

9.1A.4.3.4.3 Pedestal Friction Forces

The maximum (x or y direction) shear load (in kips) bounding all pedestals in the simulation are reported below and are obtained by inspection of the complete tabular data.

Pool	Event	Run	COF	Maximum Friction Load (kips)
Spent Fuel Pool	SSE	1	0.8	103.0
	SSE	2	0.2	46.8
	SSE	3	Random	99.3
	OBE	4	0.8	39.7
	OBE	5	0.2	31.4
	OBE	6	Random	41.4
Cask Loading Pool	SSE	7	0.8	58.9

Pool	Event	Run	COF	Maximum Friction Load (kips)
	SSE	8	0.2	30.7
	SSE	9	Random	57.5
	OBE	10	0.8	15.1
	OBE	11	0.2	15.7
	OBE	12	Random	15.4
Half full SFP	SSE	13	0.8	61.0
	SSE	14	0.2	39.6
	SSE	15	Random	84.7

9.1A.4.3.4.4 Rack Impact Loads

A freestanding rack, by definition, is a structure subject to potential impacts during a seismic event. Impacts arise from rattling of the fuel assemblies in the storage rack locations and, in some instances, from localized impacts between the racks, or between a peripheral rack and the pool wall. As in the case of most high density rack designs, limited rack to rack impacts are indicated. The following instantaneous maximum impact forces and locations are identified for each of the simulations performed. Listings are only given for those simulations within which impact occurred. It may be noted that all impact loads occurred at the bottom of the racks where the gap was modeled as only 1/8 inch. No impacts occurred for the 0.8 COF condition, since under higher friction the relative rack displacement at the base plate level was reduced to less than the 1/8" gap. The element numbering is identified in Figures 9.1A-17 through 9.1A-22.

Pool	Event	Run	COF	Maximum Impact Load (kips)	Element
Spent Fuel Pool	SSE	2	0.2	25.20	396
	SSE	3	Random	41.03	408
Half full SFP	SSE	14	0.2	47.9	213

9.1A.4.3.4.5 Rack to Wall Impacts

Storage racks do not impact the pool walls under any simulation.

9.1A.4.3.4.6 Fuel to Cell Wall Impact Loads

A review of all simulations performed allows determination of the maximum instantaneous impact load between fuel assembly and fuel cell wall at any modeled impact site.

The maximum fuel/cell wall impact load values are reported in the following table.

Pool	Event	Run	COF	Maximum Impact Load (lbs)	Rack
Spent Fuel Pool	SSE	1	0.8	641	12
	SSE	2	0.2	625	10
	SSE	3	Random	641	13
	OBE	4	0.8	370	6
	OBE	5	0.2	371	6
	OBE	6	Random	371	6
Cask Loading Pool	SSE	7	0.8	710	1
	SSE	8	0.2	590	2
	SSE	9	Random	659	2
	OBE	10	0.8	403	1
	OBE	11	0.2	378	3
	OBE	12	Random	360	1
Half full SFP	SSE	13	0.8	565	6
	SSE	14	0.2	781	4
	SSE	15	Random	840	7

Based on fuel manufacturer’s data, loads of this magnitude will not damage the fuel assembly.

9.1A.4.3.5 Rack Structural Evaluation

9.1A.4.3.5.1 Rack Stress Factors

With time history results available for pedestal normal and lateral interface forces, the limiting bending moment and shear force at the bottom casting-pedestal interface is available as a function of time. In particular, maximum values for the previously defined stress factors can be determined for every pedestal in the array of racks. With this information available, the structural integrity of the pedestal can be assessed and reported. The net section maximum (in time) bending moments and shear forces can also be determined at the bottom casting-rack cellular structure interface for each spent fuel rack in the pool. With this information in hand, the maximum stress in the limiting rack cell (box) can be evaluated.

An evaluation of the stress factors for all of the simulations performed, leads to the conclusion that all stress factors, as defined in Section 9.1A.4.3.1, are less than the mandated limit of 1.0 for the load cases examined.

From all of the simulations reported in the tables, the bounding stress factors are summarized below. The maximum stress factor is always R6, defined in section 9.1A.4.3.1.

Pool	Event	Run	COF	Maximum Stress Factor	Rack
Spent Fuel Pool	SSE	1	0.8	0.389	12
	SSE	2	0.2	0.264	3
	SSE	3	Random	0.338	12
	OBE	4	0.8	0.441	1
	OBE	5	0.2	0.423	1
	OBE	6	Random	0.442	1
Cask Loading Pool	SSE	7	0.8	0.330	2
	SSE	8	0.2	0.289	1
	SSE	9	Random	0.309	2
	OBE	10	0.8	0.378	1
	OBE	11	0.2	0.377	1
	OBE	12	Random	0.378	1

Pool	Event	Run	COF	Maximum Stress Factor	Rack
Half full SFP	SSE	13	0.8	0.241	6
	SSE	14	0.2	0.261	8
	SSE	15	Random	0.289	8

The requirements of Section 9.1A.4.3 are satisfied for the load levels considered for every limiting location in every rack in the array. Stress factors for SSE are calculated based on SSE allowable strengths, while stress factors for OBE simulations are based on OBE allowable strengths.

9.1A.4.3.5.2 Pedestal Thread Shear Stress

The complete post-processor results give thread stresses under faulted conditions for every pedestal for every rack in the pool. The average shear stress in the engagement region is given below for the limiting pedestal in each simulation.

Pool	Event	Run	COF	Maximum Thread Shear Stress (psi)	Rack
Spent Fuel Pool	SSE	1	0.8	9268	12
	SSE	2	0.2	7484	3
	SSE	3	Random	8503	1
	OBE	4	0.8	6465	1
	OBE	5	0.2	5987	1
	OBE	6	Random	6497	1
Cask Loading Pool	SSE	7	0.8	6274	3
	SSE	8	0.2	5159	1
	SSE	9	Random	5064	3
	OBE	10	0.8	3280	1
	OBE	11	0.2	3280	1
	OBE	12	Random	3280	1
Half full SFP	SSE	13	0.8	6720	6

Pool	Event	Run	COF	Maximum Thread Shear Stress (psi)	Rack
	SSE	14	0.2	7006	4
	SSE	15	Random	8121	3

The ultimate strength of the female part of the pedestal is 66,200 psi. The yield stress for this material is 21,300 psi.

The allowable shear stress for Level B conditions is 0.4 times the yield stress which gives 8,520 psi and is much larger than the maximum calculated stress value of 6,497 psi for the OBE simulations.

The allowable shear stress for Level D conditions is the lesser of: 0.72 S_y = 15,336 psi or 0.42 S_u = 27,804 psi . Therefore, the former criteria controls and the allowable is much larger than the maximum calculated stress value of 9,268 psi for the SSE condition. Therefore, thread shear stresses are acceptable under all conditions.

9.1A.4.3.5.3 Local Stresses Due to Impacts

Impact loads at the pedestal base produce stresses in the pedestal for which explicit stress limits are prescribed in the Code. However, impact loads on the cellular region of the racks produce stresses which attenuate rapidly away from the loaded region. This behavior is characteristic of secondary stresses.

Even though limits on secondary stresses are not prescribed in the Code for class 3 NF structures, evaluations must be made to ensure that the localized impacts do not lead to plastic deformations in the storage cells which affect the subcriticality of the stored fuel array.

a. Impact Loading Between Fuel Assembly and Cell Wall

Local cell wall integrity is conservatively estimated from peak impact loads. Plastic analysis is used to obtain the limiting impact load which would lead to gross permanent deformation. Fuel impacts are demonstrated not to represent a significant concern with respect to fuel rack cell deformation.

b. Impacts Between Adjacent Racks

The bottom of the storage racks will impact each other at a few locations during seismic events. Since the loading is presented edge-on to the 3/4" baseplate membrane, the distributed stresses after local deformation will be negligible. The impact loading will be distributed over a significant portion of the entire baseplate length. The resulting compressive stress

from the highest impact load is negligible. This is a conservative computation, since the simulation assumes a local impact site. Therefore, any deformation will not effect the configuration of the stored fuel.

9.1A.4.3.5.4 Assessment of Rack Fatigue Margin

Deeply submerged high density spent fuel storage racks arrayed in close proximity to each other in a free-standing configuration behave primarily as a nonlinear cantilevered structure when subjected to 3-D seismic excitations. In addition to the pulsations in the vertical load at each pedestal, lateral friction forces at the pedestal/bearing pad-liner interface, which help prevent or mitigate lateral sliding of the rack, also exert a time-varying moment in the baseplate region of the rack. The friction-induced lateral forces act simultaneously in x and y directions with the requirement that their vectorial sum does not exceed μV, where μ is the limiting interface coefficient of friction and V is the concomitant vertical thrust on the liner (at the *given* time instant). As the vertical thrust at a pedestal location changes, so does the maximum friction force, F, that the interface can exert. In summary, the horizontal friction force at the pedestal/liner interface is a function of time; its magnitude and direction of action varies during the earthquake event.

The time-varying lateral (horizontal) and vertical forces on the extremities of the support pedestals produce stresses at the root of the pedestals in the manner of an end-loaded cantilever. The stress field in the cellular region of the rack is quite complex, with its maximum values located in the region closest to the pedestal. The maximum magnitude of the stresses depends on the severity of the pedestal end loads and on the geometry of the pedestal/rack baseplate region.

Alternating stresses in metals produce metal fatigue if the amplitude of the stress cycles is sufficiently large. In high density racks designed for sites with moderate to high postulated seismic action, the stress intensity amplitudes frequently reach values above the material endurance limit, leading to expenditure of the fatigue "usage" reserve in the material.

Because the locations of maximum stress (viz., the pedestal/rack baseplate junction) and the close placement of racks, a post-earthquake inspection of the high stressed regions in the racks is not feasible. Therefore, the racks must be engineered to withstand multiple earthquakes without reliance of nondestructive inspections for post-earthquake integrity assessment. The fatigue life evaluation of racks is an integral aspect of a sound design.

A time-history analysis was performed to provide the means to obtain a complete cycle history of the stress intensities in the highly stressed regions of the rack.

To evaluate the cumulative damage factor, a finite element model of a portion of the spent fuel rack in the vicinity of a support pedestal is constructed in sufficient detail to provide an accurate assessment of stress intensities. The finite element solutions for unit pedestal loads in three orthogonal directions are combined to establish the maximum

value of stress intensity as a function of the three unit pedestal loads. Using the archived results of the spent fuel rack dynamic analyses (pedestal load histories versus time), enables a time-history of stress intensity to be established at the most limiting location. This permits establishing a set of alternating stress intensity ranges versus cycles for an SSE and an OBE event. Following ASME Code guidelines for computing U, it is found that U =0.404 due to the combined effect of one SSE and twenty OBE events. This is well below the ASME Code limit of 1.0.

9.1A.4.3.5.5 Weld Stresses

Weld locations subjected to significant seismic loading are at the bottom of the rack at the baseplate-to-cell connection, at the top of the pedestal support at the baseplate connection, and at cell-to-cell connections. Bounding values of resultant loads are used to qualify the connections.

a. Baseplate-to-Rack Cell Welds

For Level A or B conditions, Reference 55 permits an allowable weld stress of τ = .3 S_u. The allowable value may be increased for Level D by the ratio 1.8.
The highest predicted weld stress for OBE is calculated from the highest R6 value. The highest predicted weld stress is less than the allowable weld stress value.
The highest predicted weld stress for SSE is less than the allowable weld stress value as shown in Table 9.1A-20. Therefore, all weld stresses between the baseplate and cell wall base are acceptable.

b. Baseplate-to-Pedestal Welds

The weld between the baseplate and the support pedestal is checked using finite element analysis to determine the maximum stress under a Level B or Level D event. The calculated stress values are below the allowable values.

c. Cell-to-Cell Welds

Cell-to-cell connections are by a series of connecting welds along the cell height. Stresses in storage cell to cell welds develop due to fuel assembly impacts with the cell wall. These weld stresses are conservatively calculated by assuming that fuel assemblies in adjacent cells are moving out of phase with one another so that impact loads in two adjacent cells are in opposite directions; this tends to separate the two cells from each other at the weld. Table 9.1A-20 gives results for the maximum allowable load that can be transferred by these welds based on the available weld area. An upper bound on the load required to be transferred is also given in Table 9.1A-20 and is much lower than the allowable load. This upper bound

value is very conservatively obtained by applying the bounding rack-to-fuel impact load from any simulation in two orthogonal directions simultaneously, and multiplying the result by 2 to account for the simultaneous impact of two assemblies. An equilibrium analysis at the connection then yields the upper bound load to be transferred. It is seen from the results in Table 9.1A-20 that the calculated load is well below the allowable.

9.1A.4.3.5.6 Bearing Pad Analysis

To protect the pool slab from high localized dynamic loadings, bearing pads are placed between the pedestal base and the slab. Fuel rack pedestals impact on these bearing pads during a seismic event and pedestal loading is transferred to the liner. Bearing pad dimensions are set to ensure that the average pressure on the slab surface due to a static load plus a dynamic impact load does not exceed the American Concrete Institute, ACI-349 (Reference 58) limit on bearing pressures. The maximum vertical pedestal load is 291,000 lbs (SSE event). The maximum allowable concrete bearing pressure is 2,380 psi.

Calculations show that the average pressure at the slab/liner interface is well below the allowable value of 2,380 psi.

The stress distribution in the bearing pad is also evaluated. The maximum bending stress in the bearing pad under the peak vertical load is acceptable.

Therefore, the bearing pad design devised for the Callaway is appropriate for the prescribed loadings.

9.1A.4.3.5.7 Level A Evaluation

The Level A condition is not a governing condition for spent fuel racks since the general level of loading is far less than Level B loading. To illustrate this, the heaviest spent fuel rack is considered under the dead weight load. It is shown below that the maximum pedestal load is low and that further stress evaluations are unnecessary.

LEVEL A MAXIMUM PEDESTAL LOAD

Dry Weight of Largest Holtec Rack (B1 is 13x13 cells)	=	25970 lbf
Dry Weight of 169 Fuel Assemblies	=	278343 lbf
Total Dry Weight	=	304313 lbf
Total Buoyant Weight (0.87 x Total Dry Weight)	=	264752 lbf
Load per Pedestal	=	66188 lbf

The stress allowables for the normal condition is the same as for the upset condition, which resulted in a maximum pedestal load of 204,000 lbs. Since this load (and the corresponding stress throughout the rack members) is much greater than the 66,188 lb load calculated above, the upset (OBE) condition controls over normal (Gravity) condition. Therefore, no further evaluation is performed.

9.1A.4.3.5.8 Hydrodynamic Loads on Pool Walls

The maximum hydrodynamic pressures (in psi) that develop between the fuel racks and the spent fuel pool walls due to fluid coupling are listed below. The runs are selected to represent the worst case conditions.

Pool	Run	Maximum Pressure (psi)	Minimum Pressure (psi)
Spent Fuel Pool	1	10.3	-9.3
	2	11.1	-13.4
	3	9.9	-10.2
	4	4.6	-5.3
	5	4.6	-5.3
	6	4.7	-5.4
Cask Loading Pool	7	3.7	-4.5
	8	4.6	-4.9
	9	4.3	-3.6
	10	2.2	-1.9
	11	2.3	-1.9
	12	2.2	-2.0

These hydrodynamic pressures were considered in the evaluation of the Spent Fuel Building and Pool Structure.

9.1A.4.4 Fuel Pool Structure Integrity

The Callaway fuel storage pool is a safety related, seismic category I, reinforced concrete structure. Spent fuel is to be placed within storage racks located in the fuel storage pool. The fuel storage pool includes the spent fuel pool and the cask loading pool with fuel storage racks installed. The area is collectively referred to in this section as the fuel pool structure. An analysis was performed to demonstrate the structural

adequacy of the pool structure, as required by Section IV of the USNRC OT Position Paper (Reference 63).

The fuel storage pool regions are analyzed using the finite element method. Results for individual load components are combined using factored load combinations mandated by SRP 3.8.4 (Reference 64) based on the "ultimate strength" design method. It is demonstrated that for the critical bounding factored load combinations, structural integrity is maintained when the pools are assumed to be fully loaded with spent fuel racks, as shown in Figure 9.1-2 with all storage locations occupied by fuel assemblies.

The regions examined in for the fuel storage pool include the floor slabs and the highly loaded wall sections adjoining the slabs. Both moment and shear capabilities are checked for concrete structural integrity. Local punching and bearing integrity of the slab in the vicinity of a rack module support pedestal pad is evaluated. All structural capacity calculations are made using design formulas meeting the requirements of the American Concrete Institute (ACI).

9.1A.4.4.1 Description of Fuel Storage Pool Structure

The SFP is located inside the Fuel Building and is supported on a two way, reinforced concrete base mat which is founded six feet below grade. The minimum thickness of the mat is 6.5 feet and the mat beneath the Spent Fuel Pool is thirteen feet thick. The Cask Loading Pit is located to the South of the SFP and is supported by the base mat which is 7.5 feet thick in this vicinity. The SFP and Cask Loading Pit are separated by a three foot thick reinforced concrete wall. Figure 9.1A-23 shows an isometric view of the SFP, Cask Loading Pool and surrounding major structural features of interest (ie., Fuel Transfer Canal and Cask Washdown Pit).

[redacted]

9.1A.4.4.2 Definition of Loads

Pool structural loading involves the following discrete components:

9.1A.4.4.2.1 Static Loading (Dead Loads and Live Loads)

1) Dead weight of pool structure includes the weight of the Fuel Building concrete upper structure.

2) Maximum dead weight of rack modules and fuel assemblies stored in the modules based on 2363 storage locations in the Spent Fuel Pool and 279 storage locations in the Cask Loading Pool, as shown in Figure 9.1-2.

3) Dead weight of a shipping cask including yoke of 250 kips.

4) The Cask Handling Crane and Spent Fuel Handling Machine (Refueling Platform) are designed to move along the N-S direction. The dead weight and the rated lift weight of these cranes are considered as dead load and live load, respectively.

5) The hydrostatic water pressure.

9.1A.4.4.2.2 Seismic Induced Loads

1) Vertical loads transmitted by the rack support pedestals to the slab during a SSE or OBE seismic event.

2) Hydrodynamic inertia loads due to the contained water mass and sloshing loads (considered in accordance with (Reference 66)) which arise during a seismic event.

3) Hydrodynamic pressures between racks and pool walls caused by rack motion in the pool during a seismic event.

4) Seismic inertia force of the walls and slab.

9.1A.4.4.2.3 Thermal Loading

Thermal loading is defined by the temperature existing at the faces of the pool concrete walls and slabs. Two thermal loading conditions are evaluated: The normal operating temperature and the accident temperature. The effect of gamma heating on the concrete was also considered and requires the implementation of administrative controls to maintain concrete temperatures within acceptable ranges, as discussed in section 9.1A.4.4.5.

9.1A.4.4.2.4 Pool Water Loading

The loadings described above were considered for two possible scenarios: one considers the Cask Loading Pool full of water and the other considers the Cask Loading Pool empty.

9.1A.4.4.3 Analysis Methodology

9.1A.4.4.3.1 Finite Element Analysis Model

The finite element model encompasses the entire Spent Fuel Pool and three other reinforced concrete structures located immediately adjacent to the Spent Fuel Pool (the Cask Loading Pool, the Transfer Canal and the Cask Washdown Pit). The interaction with the rest of the Fuel Building reinforced concrete, which is not included in the finite-

element model, is simulated by imposing appropriate boundary conditions. The structural area of interest for the fuel storage pool includes only two the spent fuel pool and the cask loading pool. However, by augmenting these areas of interest with the addition of the Transfer Canal and the Cask Washdown Pit, the constructed finite-element model and numerical investigation are enhanced because the perturbation induced by the boundary conditions on the stress field distribution for the area of interest is minimized.

The preprocessing capabilities of the STARDYNE computer code (Reference 67) are used to develop the 3-D finite-element model. The STARDYNE finite-element model contains 9866 nodes, 3696 solid type finite-elements, 4411 plate type finite-elements and 16 hydro-dynamic masses.

The dynamic behavior of the water mass contained in the Spent Fuel Pool and Cask Loading Pool during a seismic event is modeled according to the guidelines set in TID-7024 (Reference 66).

To simulate the interaction between the modeled region and the rest of the Fuel Building a number of boundary restraints were imposed upon the described finite-element model.

The behavior of the reinforced concrete existing in the structural elements (walls, slab and mat) is considered elastic and isotropic. The elastic characteristics of the concrete are independent of the reinforcement contained in each structural element for the case when the un-cracked cross-section is assumed. This assumption is valid for all load cases with the exception of the thermal loads, where for a more realistic description of the reinforced concrete cross-section including the assumption of cracked concrete is used. To simulate the variation and the degree of cracking patterns, the original elastic modulus of the concrete is modified in accordance with Reference (Reference 65).

9.1A.4.4.3.2 Analysis Technique

The structural region isolated from the Fuel Building and comprised of four pools (the Spent Fuel Pool, the Cask Loading Pool, the Transfer Canal and the Cask Washdown Pit) is numerically investigated using the finite element method. The pool walls and their supporting reinforced concrete mat are represented by a 3-D finite-element model.

The individual loads considered in the analysis are grouped in five categories: dead load (weight of the pool structure, dead weight of the rack modules and stored fuel, dead weight of the reinforced concrete Fuel Building upper structure , the dead weight of the Cask Handling Crane (CHC) and the Spent Fuel Handling Machine (SFHM), and the hydro-static pressure of the contained water), live loads (CHC and SFHM suspended loads), thermal loads (the thermal gradient through the pool walls and slab for normal operating and accident conditions) and the seismic induced forces (structural seismic forces, interaction forces between the rack modules and the pool slab, seismic loads due to self-excitation of the pool structural elements and contained water, and seismic hydro-dynamic interaction forces between the rack modules and the pool walls for both OBE

and SSE conditions). The dead and thermal loads are considered static acting loads, while the seismic induced loads are time-dependent.

The material behavior under all type of loading conditions is described as elastic and isotropic representing the uncracked characteristics of the structural elements cross-section, with the exception of the thermal load cases where the material elasticity modulus is reduced in order to simulate the variation and the degree of the crack patterns. This approach (Reference 65) acknowledges the self-relieving nature of the thermal loads. The degree of reduction of the elastic modulus is calculated based on the average ultimate capacity of the particular structural element.

The numerical solution (displacements and stresses) for the cases when the structure was subjected to dead and thermal loads is a classical static solution. For the time-dependent seismic induced loads the displacement and stress field are calculated employing the spectra (shock) method. This method requires a prior modal eigenvector and eigenvalues extraction. Natural frequencies of the 3-D finite-element model are calculated up to the rigid range, considered as greater than 34 Hz. Three independent orthogonal acceleration spectra are applied to the model. The acceleration spectra are considered to act simultaneously in three-directions. The SRSS method is used to sum the similar quantities calculated for each direction.

Results for individual load cases are combined using the factored load combinations discussed below considering two scenarios: first, when the Spent Fuel Pool and the Cask Storage Pool are full of water (SC1); and second, when only the Spent Fuel Pool (SC2) is full of water. The combined stress resultants are compared with the ultimate moments and shear capacities of all structural elements pertinent to the Spent Fuel Pool and Cask Storage Pool, which are calculated in accordance with the ACI 318-89 to develop the safety factors.

9.1A.4.4.3.3 Load Combinations

The various individual load cases are combined in accordance with the NUREG-0800 Standard Review Plan (Reference 64) requirements with the intent to obtain the most critical stress fields for the investigated reinforced concrete structural elements.

For "Service Load Conditions" the following load combinations are:

- Load Combination No. 1 = 1.4* D + 1.7*L

- Load Combination No. 2 = 1.4* D + 1.7*L + 1.9*E

- Load Combination No. 3 = 1.4* D + 1.7*L - 1.9*E

- Load Combination No. 4 = 0.75* (1.4* D + 1.7*L + 1.9*E +1.7*T_o)

- Load Combination No. 5 = 0.75* (1.4* D + 1.7*L - 1.9*E +1.7*T_o)

- Load Combination No. 6 = 1.2*D + 1.9*E

- Load Combination No. 7 = 1.2*D - 1.9*E

For "Factored Load Conditions" the following load combinations are:

- Load Combination No. 8 = D + L + T_o + E’

- Load Combination No. 9 = D + L + T_o - E’

- Load Combination No. 10 = D + L + T_a + 1.25*E

- Load Combination No. 11 = D + L + T_a - 1.25*E

- Load Combination No. 12 = D + L + T_a + E’

- Load Combination No. 13 = D + L + T_a - E’

where:

D = dead loads;

L = live loads;

T_o = thermal load during normal operation;

T_a = thermal load under accident condition;

E = OBE earthquake induced loads;

E’ = SSE earthquake induced loads.

9.1A.4.4.3.4 Results of Analyses

The STARDYNE computer code was used to obtain the stress and displacement fields for 18 individual load cases covering the two scenarios: SC1 (spent fuel pool and cask loading pool full of water) and SC2 (spent fuel pool fuel pool full of water and the cask loading pool empty).

The STARDYNE postprocessing capability was employed to form the appropriate load combinations and to establish the limiting bending moments and shear forces in various sections of the pool structure. A total of 26 load combinations were computed. Section limit strength formulas for bending loading were computed using appropriate concrete

and reinforcement strengths. For Callaway the concrete and reinforcement allowable strengths are:

concrete f_c' = 4,000 psi

reinforcement f_y = 60,000 psi

Table 9.1A-21 shows results from potentially limiting load combinations for the bending strength of the slab and walls. For each section, we define the limiting safety margins as the limited strength bending moment or shear force defined by ACI for that structural section divided by the calculated bending moment or shear force (from the finite element analyses). The major regions of the pool structure consist of six concrete walls delimiting the SFP and Cask Storage Pool. Each area is searched independently for the maximum bending moments in different bending directions and for the maximum shear forces. Safety margins are determined from the calculated maximum bending moments and shear forces based on the local strengths. The procedures are repeated for all the potential limiting load combinations. Therefore, limiting safety margins are determined.

Table 9.1A-21 demonstrates that the limiting safety margins for all sections are above 1.0 as required.

Table 9.1A-22 shows results of shear capacity calculations for the slab and walls. Calculated margins are again to be compared with an allowable margin of 1.0.

9.1A.4.4.4 Pool Liner

The pool liner is subject to in-plate strains due to movement of the rack support feet during the seismic event. Analyses are performed to establish that the liner will not tear or rupture under limiting loading conditions in the pool, and that there is no fatigue problem under the condition of 1 SSE event plus 20 OBE events. These analyses are based on loadings imparted from the most highly loaded pedestal in the pool assumed to be positioned in the most unfavorable position. Bearing strength requirements are shown to be satisfied by conservatively analyzing the most highly loaded pedestal located in the worst configuration with respect to underlying leak chases.

9.1A.4.4.5 Administrative Controls on Fuel Storage

The effect of gamma heating was evaluated along with the temperature differentials across the wall from normal and accident conditions. The concrete and rebar stresses were shown to be acceptable for all conditions. However, gamma heating produces concrete temperatures above 150°F under some short term conditions for the 36 inch thick wall along the south side of the Spent Fuel Pool. However, the excessive temperature will be of short duration due to the rapid reduction in gamma bombardment over the cooling period of the fuel.

Although temperatures in excess of the 150°F range are allowed by the ACI code, the effect from gamma heating can be remedied by storage of fuel with longer cooling time along the pool periphery. Therefore, in lieu of performing additional evaluations to determine the acceptability of the gamma heating on the 36" thick wall, administrative controls are provided to ensure spent fuel is cooled at least one year prior to storage along the peripheral rack cells on the South end of the Spent Fuel Pool, or the peripheral rack cells on the North end of the Cask Loading Pool (i.e., in storage module cells adjacent to the 36" wall separating the two pools).

9.1A.4.4.6 Conclusions

Regions affected by loading the fuel pool completely with high density racks are examined for structural integrity under bending and shearing action. It is determined that adequate safety margins exist assuming that all racks are fully loaded with a bounding fuel weight and that the factored load combinations are checked against the appropriate structural design strengths. It is also shown that local loading on the liner does not compromise liner integrity under a postulated fatigue condition and that concrete bearing strength limits are not exceeded.

9.1A.5 Administrative Control of Fuel Movement and Storage in Regions 2 and 3

Control of fuel movement in the plant and the placement of fuel in Region 2 and 3 of the Fuel Storage Pool is under strict administrative control. This control precludes the possibility of erroneous placement of fuel which has not attained the required burnup (see Figure 9.1A-3) in Region 2 or 3 of the Fuel Storage Pool.

Movement of spent fuel or fuel handling in the fuel storage pool with spent fuel present is carried out under the supervision of a senior reactor operator (SRO), except under other conditions, such as fuel movement for fuel that has been packaged for transport. Under these other conditions, fuel movement on site is carried out by a trained operator. Detailed approved procedures are used which give step-by-step action for each fuel movement. When new fuel is received on site, a fuel status record is initiated for each fuel assembly which records the assembly movement throughout the plant including new fuel storage, spent fuel storage and reactor core locations. Material transfer reports are also completed which record, sequentially, each fuel assembly movement.

Additionally, when the fuel in the fuel storage pool is to be transferred from Region 1 to Region 2 or 3, an inventory of the fuel in Region 1 of the fuel storage pool will be completed. Following this verification, fuel from Region 1 may be transferred to Region 2 or 3.

Prior to the start of transfer of fuel to Region 2 or 3, the history of each fuel assembly in Region 1 is reviewed and calculations are performed to determine the amount of burnup each assembly has received. Once it has been determined that a fuel assembly has attained the required burnup, it is added to the list of assemblies designated for movement to Region 2 or 3 of the pool.

Fuel is moved through the use of the spent fuel bridge crane described in Section 9.1.4.2.2 and shown in Figures 9.1-8 and 9.1-9.

In addition to these precautions and controls, a "Special Nuclear Material Physical Inventory" is implemented annually which verifies fuel location in the new fuel storage racks and fuel storage pool.

These controls, procedures, checks and verifications ensure that the fuel stored in each location in Region 2 or 3 is the fuel that was designated for storage in that location and that the fuel has attained the required burnup.

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TABLE 9.1A-1 SUMMARY OF THE CRITICALITY SAFETY ANALYSES FOR THE MZTR STORAGE CONFIGURATION

Design Basis Burnups at 5.0 ± 0.05 wt% ^{235}U initial enrichment	0 in Region 1	
	50 in Region 2	
	40.75 in Region 3	
Temperature for Analysis	20°C	
Uncertainties		
Manufacturing tolerances (Table 9.1A.5)	± 0.0059	
Water-gap (horizontal)	± 0.0014	
Water-gap (vertical)	± 0.0003	
Burnup (Region 2)	± 0.0056	
Burnup (Region 3)	± 0.0001	
Eccentricity in position	negative	
KENO5a statistics (95%/95%)	± 0.0003	
Bias statistics (95%/95%)	± 0.0012	
Statistical combination of uncertainties*	± 0.0084	
Region 1 Fuel Description	5.0 wt% ^{235}U with 16 IFBA rods	4.6 wt% ^{235}U with no IFBA rods
Reference k_{eff} (KENO5a)	0.9266	0.9294
Total Uncertainty (above)	0.0084	0.0084
Calculational Bias (see Appendix A)	0.0030	0.0030
Axial Burnup Effect	negative	negative
Temperature Correction to 4°C (39°F)	0.0020	0.0020
Pellet Density Correction	0.0022	0.0022
Maximum k_{eff}	0.9422	0.9450
Limiting k_{eff}	0.9500	0.9500

* Square root of the sum of the squares.

TABLE 9.1A-2 SUMMARY OF THE CRITICALITY SAFETY ANALYSES FOR THE INTERIM CHECKERBOARD STORAGE CONFIGURATION

Temperature for Analysis		20°C
Uncertainties		
Manufacturing tolerances (Table 9.1A.5)	± 0.0059	
Water-gap (horizontal)	± 0.0014	
Water-gap (vertical)	± 0.0003	
Burnup (Region 2)	N/A	
Burnup (Region 3)	N/A	
Eccentricity in position	negative	
KENO5a statistics (95%/95%)	± 0.0004	
Bias statistics (95%/95%)	± 0.0012	
Statistical combination of uncertainties*	± 0.0062	

Fuel Description	5.0 wt%^{235}U with 16 IFBA rods	4.6 wt%^{235}U with no IFBA rods
Reference k_{eff} (KENO5a)	0.8439	0.8490
Total Uncertainty (above)	0.0062	0.0062
Calculational Bias (see Appendix A)	0.0030	0.0030
Axial Burnup Effect	negative	negative
Temperature Correction to 4°C (39°F)	0.0020	0.0020
Pellet Density Correction	0.0022	0.0022
Maximum k_{eff}	0.8573	0.8624
Limiting k_{eff}	0.9500	0.9500

* Square root of the sum of the squares.

TABLE 9.1A-3 REACTIVITY EFFECTS OF ABNORMAL AND ACCIDENT CONDITIONS

Abnormal/Accident Conditions	Reactivity Effect
Temperature Increase (above 4°C)	Negative (Table 9.1A-6)
Void (boiling)	Negative (Table 9.1A-6)
Assembly Drop (on top of rack)	Negligible
Assembly Drop (adjacent to rack)	Positive - controlled by < 500 ppm soluble boron
Lateral Rack Movement	Included in Tolerances
Misplacement of a fresh fuel assembly	Positive - controlled by 500 ppm soluble boron

TABLE 9.1A-4 DESIGN BASIS FUEL ASSEMBLY SPECIFICATIONS

Fuel Rod Data			
Assembly type	OFA	Standard	Vantage-5H
Fuel pellet outside diameter, in.	0.3088	0.3225	0.3225
Cladding thickness, in.	0.0225	0.0225	0.0225
Cladding outside diameter, in.	0.360	0.374	0.374
Cladding material	Zr	Zr	Zr
Pellet density, % T.D.	95.0	95.0	95.0
Maximum nominal enrichment, wt% ^{235}U	5.0	5.0	5.0
Fuel Assembly Data			
Fuel rod array	17 x 17	17 x 17	17 x 17
Number of fuel rods	264	264	264
Fuel rod pitch, in.	0.496	0.496	0.496
Number of control rod guide and instrument thimbles	25	25	25
Thimble outside diameter, in.	0.474	0.482	0.474
Thimble thickness, in.	0.016	0.016	0.016
Number of IFBA rods	16	16	16
Active fuel Length, in.	144	144	144

TABLE 9.1A-5 REACTIVITY EFFECTS OF MANUFACTURING TOLERANCES

Tolerance	Reactivity Effect, Δk
Minimum boral loading	±0.0044
Minimum boral width	±0.0010
Minimum box I.D.	±0.0016
Maximum SS thickness	±0.0002
Density tolerance	±0.0026
Enrichment tolerance (5.05%, 5.0% nominal)	±0.0023
Total (statistical sum)*	±**0.0059**

*   Square root of the sum of the squares.

TABLE 9.1A-6 REACTIVITY EFFECTS OF TEMPERATURE AND VOID

	Reactivity Effect, Δk		
Case	Region 1 (Fresh fuel)	Region 2 (50 MWd/kgU)	Region 3 (40.75 MWd/kgU)
4°C (39°F)	reference	reference	reference
20°C (68°F)	-0.002	-0.0036	-0.0034
60°C (140°F)	-0.0095	-0.0137	-0.0134
120°C (248°F)	-0.0252	-0.0314	-0.0313
120°C w/ 10% void	-0.0496	-0.0484	-0.0501

TABLE 9.1A-7 SUMMARY OF CRITICALITY BENCHMARK CALCULATIONS

	Reference	Identification	Enrich.	Calculated $k_{eff} \pm 1\sigma$		EALF † (eV)	
				MCNP4a	KENO5a	MCNP4a	KENO5a
1	B&W-1484 (Rf. 23)	Core I	2.46	0.9964 ± 0.0010	0.9898± 0.0006	0.1759	0.1753
2	B&W-1484 (Rf. 23)	Core II	2.46	1.0008 ± 0.0011	1.0015 ± 0.0005	0.2553	0.2446
3	B&W-1484 (Rf. 23)	Core III	2.46	1.0010 ± 0.0012	1.0005 ± 0.0005	0.1999	0.1939
4	B&W-1484 (Rf. 23)	Core IX	2.46	0.9956 ± 0.0012	0.9901 ± 0.0006	0.1422	0.1426
5	B&W-1484 (Rf. 23)	Core X	2.46	0.9980 ± 0.0014	0.9922 ± 0.0006	0.1513	0.1499
6	B&W-1484 (Rf. 23)	Core XI	2.46	0.9978 ± 0.0012	1.0005 ± 0.0005	0.2031	0.1947
7	B&W-1484 (Rf. 23)	Core XII	2.46	0.9988 ± 0.0011	0.9978 ± 0.0006	0.1718	0.1662
8	B&W-1484 (Rf. 23)	Core XIII	2.46	1.0020 ± 0.0010	0.9952 ± 0.0006	0.1988	0.1965
9	B&W-1484 (Rf. 23)	Core XIV	2.46	0.9953 ± 0.0011	0.9928 ± 0.0006	0.2022	0.1986
10	B&W-1484 (Rf. 23)	Core XV ††	2.46	0.9910 ± 0.0011	0.9909 ± 0.0006	0.2092	0.2014
11	B&W-1484 (Rf. 23)	Core XVI ††	2.46	0.9935 ± 0.0010	0.9889 ± 0.0006	0.1757	0.1713
12	B&W-1484 (Rf. 23)	Core XVII	2.46	0.9962 ± 0.0012	0.9942 ± 0.0005	0.2083	0.2021
13	B&W-1484 (Rf. 23)	Core XVIII	2.46	1.0036 ± 0.0012	0.9931 ± 0.0006	0.1705	0.1708
14	B&W-1484 (Rf. 23)	Core XIX	2.46	0.9961 ± 0.0012	0.9971 ± 0.0005	0.2103	0.2011
15	B&W-1484 (Rf. 23)	Core XX	2.46	1.0008 ± 0.0011	0.9932 ± 0.0006	0.1724	0.1701
16	B&W-1484 (Rf. 23)	Core XXI	2.46	0.9994 ± 0.0010	0.9918 ± 0.0006	0.1544	0.1536
17	B&W-1645 (Rf. 24)	S-type Fuel, w/886 ppm B	2.46	0.9970 ± 0.0010	0.9924 ± 0.0006	1.4475	1.4680
18	B&W-1645 (Rf. 24)	S-type Fuel, w/746 ppm B	2.46	0.9990 ± 0.0010	0.9913 ± 0.0006	1.5463	1.5660
19	B&W-1645 (Rf. 24)	SO-type Fuel, w/1156 ppm B	2.46	0.9972 ± 0.0009	0.9949 ± 0.0005	0.4241	0.4331
20	B&W-1810 (Rf. 25)	Case 1 1337 ppm B	2.46	1.0023 ± 0.0010	NC	0.1531	NC
21	B&W-1810 (Rf. 25)	Case 12 1899 ppm B	2.46/4.02	1.0060 ± 0.0009	NC	0.4493	NC
22	French (Rf. 26)	Water Moderator 0 gap	4.75	0.9966 ± 0.0013	NC	0.2172	NC
23	French (Rf. 26)	Water Moderator 2.5 cm gap	4.75	0.9952 ± 0.0012	NC	0.1778	NC
24	French (Rf. 26)	Water Moderator 5 cm gap	4.75	0.9943 ± 0.0010	NC	0.1677	NC
25	French (Rf. 26)	Water Moderator 10 cm gap	4.75	0.9979 ± 0.0010	NC	0.1736	NC

TABLE 9.1A-7 (Sheet 2)

	Reference	Identification	Enrich.	Calculated $k_{eff} \pm 1\sigma$		EALF † (eV)	
				MCNP4a	KENO5a	MCNP4a	KENO5a
26	PNL-3602 (Rf. 27)	Steel Reflector, 0 separation	2.35	NC	1.0004 ± 0.0006	NC	0.1018
27	PNL-3602 (Rf. 27)	Steel Reflector, 1.321 cm sepn.	2.35	0.9980 ± 0.0009	0.9992 ± 0.0006	0.1000	0.0909
28	PNL-3602 (Rf. 27)	Steel Reflector, 2.616 cm sepn	2.35	0.9968 ± 0.0009	0.9964 ± 0.0006	0.0981	0.0975
29	PNL-3602 (Rf. 27)	Steel Reflector, 3.912 cm sepn.	2.35	0.9974 ± 0.0010	0.9980 ± 0.0006	0.0976	0.0970
30	PNL-3602 (Rf. 27)	Steel Reflector, infinite sepn.	2.35	0.9962 ± 0.0008	0.9939 ± 0.0006	0.0973	0.0968
31	PNL-3602 (Rf. 27)	Steel Reflector, 0 cm sepn.	4.306	NC	1.0003 ± 0.0007	NC	0.3282
32	PNL-3602 (Rf. 27)	Steel Reflector, 1.321 cm sepn.	4.306	0.9997 ± 0.0010	1.0012 ± 0.0007	0.3016	0.3039
33	PNL-3602 (Rf. 27)	Steel Reflector, 2.616 cm sepn.	4.306	0.9994 ± 0.0012	0.9974 ± 0.0007	0.2911	0.2927
34	PNL-3602 (Rf. 27)	Steel Reflector, 5.405 cm sepn.	4.306	0.9969 ± 0.0011	0.9951 ± 0.0007	0.2828	0.2860
35	PNL-3602 (Rf. 27)	Steel Reflector, Infinite sepn. ††	4.306	0.9910 ± 0.0020	0.9947 ± 0.0007	0.2851	0.2864
36	PNL-3602 (Rf. 27)	Steel Reflector, with Boral Sheets	4.306	0.9941 ± 0.0011	0.9970 ± 0.0007	0.3135	0.3150
37	PNL-3926 (Rf. 28)	Lead Reflector, 0 cm sepn.	4.306	NC	1.0003 ± 0.0007	NC	0.3159
38	PNL-3926 (Rf. 28)	Lead Reflector, 0.55 cm sepn.	4.306	1.0025 ± 0.0011	0.9997 ± 0.0007	0.3030	0.3044
39	PNL-3926 (Rf. 28)	Lead Reflector, 1.956 cm sepn.	4.306	1.0000 ± 0.0012	0.9985 ± 0.0007	0.2883	0.2930
40	PNL-3926 (Rf. 28)	Lead Reflector, 5.405 cm sepn.	4.306	0.9971 ± 0.0012	0.9946 ± 0.0007	0.2831	0.2854
41	PNL-2615 (Rf. 29)	Experiment 004/032 - no absorber	4.306	0.9925 ± 0.0012	0.9950 ± 0.0007	0.1155	0.1159
42	PNL-2615 (Rf. 29)	Experiment 030 - Zr plates	4.306	NC	0.9971 ± 0.0007	NC	0.1154
43	PNL-2615 (Rf. 29)	Experiment 013 - Steel plates	4.306	NC	0.9965 ± 0.0007	NC	0.1164
44	PNL-2615 (Rf. 29)	Experiment 014 - Steel plates	4.306	NC	0.9972 ± 0.0007	NC	0.1164
45	PNL-2615 (Rf. 29)	Exp. 009 1.05% Boron-Steel plates	4.306	0.9982 ± 0.0010	0.9981 ± 0.0007	0.1172	0.1162
46	PNL-2615 (Rf. 29)	Exp. 012 1.62% Boron-Steel plates	4.306	0.9996 ± 0.0012	0.9982 ± 0.0007	0.1161	0.1173
47	PNL-2615 (Rf. 29)	Exp. 031 - Boral plates	4.306	0.9994 ± 0.0012	0.9969 ± 0.0007	0.1165	0.1171
48	PNL-7167 (Rf. 30)	Experiment 214R - with flux trap	4.306	0.9991 ± 0.0011	0.9956 ± 0.0007	0.3722	0.3812
49	PNL-7167 (Rf. 30)	Experiment 214V3 - with flux trap	4.306	0.9969 ± 0.0011	0.9963 ± 0.0007	0.3742	0.3826
50	PNL-4267 (Rf. 31)	Case 173 - 0 ppm B	4.306	0.9974 ± 0.0012	NC	0.2893	NC

TABLE 9.1A-7 (Sheet 3)

	Reference	Identification	Enrich.	Calculated $k_{eff} \pm 1\sigma$		EALF † (eV)	
				MCNP4a	KENO5a	MCNP4a	KENO5a
51	PNL-4267 (Rf. 31)	Case 177 - 2550 ppm B	4.306	1.0057 ± 0.0010	NC	0.5509	NC
52	PNL-5803 (Rf. 32)	MOX Fuel - Type 3.2 Exp. 21	20% Pu	1.0041 ± 0.0011	1.0046 ± 0.0006	0.9171	0.8868
53	PNL-5803 (Rf. 32)	MOX Fuel - Type 3.2 Exp. 43	20% Pu	1.0058 ± 0.0012	1.0036 ± 0.0006	0.2968	0.2944
54	PNL-5803 (Rf. 32)	MOX Fuel - Type 3.2 Exp. 13	20% Pu	1.0083 ± 0.0011	0.9989 ± 0.0006	0.1665	0.1706
55	PNL-5803 (Rf. 32)	MOX Fuel - Type 3.2 Exp. 32	20% Pu	1.0079 ± 0.0011	0.9966 ± 0.0006	0.1139	0.1165
56	WCAP-3385 (Rf. 33)	Saxton Case 52 PuO2 0.52" pitch	6.6% Pu	0.9996 ± 0.0011	1.0005 ± 0.0006	0.8665	0.8417
57	WCAP-3385 (Rf. 33)	Saxton Case 52 U 0.52" pitch	5.74	1.0000 ± 0.0010	0.9956 ± 0.0007	0.4476	0.4580
58	WCAP-3385 (Rf. 33)	Saxton Case 56 PuO2 0.56" pitch	6.6% Pu	1.0036 ± 0.0011	1.0047 ± 0.0006	0.5289	0.5197
59	WCAP-3385 (Rf. 33)	Saxton Case 56 borated PuO2	6.6% Pu	1.0008 ± 0.0010	NC	0.6389	NC
60	WCAP-3385 (Rf. 33)	Saxton Case 56 U 0.56" pitch	5.74	0.9994 ± 0.0011	0.9967 ± 0.0007	0.2923	0.2954
61	WCAP-3385 (Rf. 33)	Saxton Case 79 PuO2 0.79" pitch	6.6% Pu	1.0063 ± 0.0011	1.0133 ± 0.0006	0.1520	0.1555
62	WCAP-3385 (Rf. 33)	Saxton Case 79 U 0.79" pitch	5.74	1.0039 ± 0.0011	1.0008 ± 0.0006	0.1036	0.1047

Notes: NC stands for not calculated.

† EALF is the energy of the average lethargy causing fission.

†† These experimental results appear to be statistical outliers (>3σ) suggesting the possibility of unusually large experimental error. Although they could justifiably be excluded, for conservatism, they were retained in determining the calculational basis.

TABLE 9.1A-8 COMPARISON OF MCNP4A AND KENO5A CALCULATED REACTIVITIES† FOR VARIOUS ENRICHMENTS

Enrichment	Calculated $k_{eff} \pm 1\sigma$	
	MCNP4a	**KENO5a**
3.0	0.8465 ± 0.0011	0.8478 ± 0.0004
3.5	0.8820 ± 0.0011	0.8841 ± 0.0004
3.75	0.9019 ± 0.0011	0.8987 ± 0.0004
4.0	0.9132 ± 0.0010	0.9140 ± 0.0004
4.2	0.9276 ± 0.0011	0.9237 ± 0.0004
4.5	0.9400 ± 0.0011	0.9388 ± 0.0004

† Based on the GE 8x8R fuel assembly.

TABLE 9.1A-9 MCNP4A CALCULATED REACTIVITIES FOR CRITICAL EXPERIMENTS WITH NEUTRON ABSORBERS

Ref.	**Experiment**		**Δk Worth of Absorber**	**MCNP4a Calculated $k_{eff} \pm 1_{\sigma}$**	**EALF† (eV)**
29	PNL-2615	Boral Sheet	0.0139	0.9994±0.0012	0.1165
23	B&W-1484	Core XX	0.0165	1.0008±0.0011	0.1724
29	PNL-2615	1.62% Boron-steel	0.0165	0.9996±0.0012	0.1161
23	B&W-1484	Core XIX	0.0202	0.9961±0.0012	0.2103
23	B&W-1484	Core XXI	0.0243	0.9994±0.0010	0.1544
23	B&W-1484	Core XVII	0.0519	0.9962±0.0012	0.2083
27	PNL-3602	Boral Sheet	0.0708	0.9941±0.0011	0.3135
23	B&W-1484	Core XV	0.0786	0.9910±0.0011	0.2092
23	B&W-1484	Core XVI	0.0845	0.9935±0.0010	0.1757
23	B&W-1484	Core XIV	0.1575	0.9953±0.0011	0.2022
23	B&W-1484	Core XIII	0.1738	1.0020±0.0011	0.1988
30	PNL-7167	Expt 214R flux trap	0.1931	0.9991±0.0011	0.3722

† **EALF is the energy of the average lethargy causing fission.**

TABLE 9.1A-10 COMPARISON OF MCNP4A AND KENO5A CALCULATED REACTIVITIES† FOR VARIOUS ^{10}B LOADINGS

^{10}B, g/cm^2	Calculated $k_{eff} \pm 1\sigma$	
	MCNP4a	**KENO5a**
0.005	1.0381 ± 0.0012	1.0340 ± 0.0004
0.010	0.9960 ± 0.0010	0.9941 ± 0.0004
0.015	0.9727 ± 0.0009	0.9713 ± 0.0004
0.020	0.9541 ± 0.0012	0.9560 ± 0.0004
0.025	0.9433 ± 0.0011	0.9428 ± 0.0004
0.03	0.9325 ± 0.0011	0.9338 ± 0.0004
0.035	0.9234 ± 0.0011	0.9251 ± 0.0004
0.04	0.9173 ± 0.0011	0.9179 ± 0.0004

† Based on 4.5% enriched GE 8x8R fuel assembly.

TABLE 9.1A-11 CALCULATIONS FOR CRITICAL EXPERIMENTS WITH THICK LEAD AND STEEL REFLECTORS†

Ref.	Case	E, wt%	Separation, cm	MCNP4a $k_{eff} \pm 1\sigma$	KENO5a $k_{eff} \pm 1\sigma$
27	Steel Reflector	2.35	1.321	0.9980±0.0009	0.9992±0.0006
		2.35	2.616	0.9968±0.0009	0.9964±0.0006
		2.35	3.912	0.9974±0.0010	0.9980±0.0006
		2.35	∞	0.9962±0.0008	0.9939±0.0006
27	Steel Reflector	4.306	1.321	0.9997±0.0010	1.0012±0.0007
		4.306	2.616	0.9994±0.0012	0.9974±0.0007
		4.306	3.405	0.9969±0.0011	0.9951±0.0007
		4.306	∞	0.9910±0.0020	0.9947±0.0007
28	Lead Reflector	4.306	0.55	1.0025±0.0011	0.9997±0.0007
		4.306	1.956	1.0000±0.0012	0.9985±0.0007
		4.306	5.405	0.9971±0.0012	0.9946±0.0007

† Arranged in order of increasing reflector-fuel spacing.

TABLE 9.1A-12 CALCULATIONS FOR CRITICAL EXPERIMENTS WITH VARIOUS SOLUBLE BORON CONCENTRATIONS

Reference	**Experiment**	**Boron Concentration, ppm**	**Calculated $k_{eff} \pm 1\sigma$**	
			MCNP4a	**KENO5a**
31	PNL-4267	0	0.9974 ± 0.0012	-
24	B&W-1645	886	0.9970 ± 0.0010	0.9924 ± 0.0006
25	B&W-1810	1337	1.0023 ± 0.0010	-
25	B&W-1810	1899	1.0060 ± 0.0009	-
31	PNL-4267	2550	1.0057 ± 0.0010	-

TABLE 9.1A-13 CALCULATIONS FOR CRITICAL EXPERIMENTS WITH MOX FUEL

Reference	Case+	MCNP4a		KENO5a	
		$k_{eff} \pm 1\sigma$	EALF++	$k_{eff} \pm 1\sigma$	EALF++
PNL-5803 (Ref. 32)	MOX Fuel - Exp. No. 21	1.0041±0.0011	0.9171	1.0046±0.0006	0.8868
	MOX Fuel - Exp. No. 43	1.0058±0.0012	0.2968	1.0036±0.0006	0.2944
	MOX Fuel - Exp. No. 13	1.0083±0.0011	0.1665	0.9989±0.0006	0.1706
	MOX Fuel - Exp. No. 32	1.0079±0.0011	0.1139	0.9966±0.0006	0.1165
WCAP-3385-54 (Ref. 33)	Saxton @ 0.52" pitch	0.9996±0.0011	0.8665	1.0005±0.0006	0.8417
	Saxton @ 0.56" pitch	1.0036±0.0011	0.5289	1.0047±0.0006	0.5197
	Saxton @ 0.56" pitch borated	1.0008±0.0010	0.6389	NC	NC
	Saxton @ 0.79" pitch	1.0063±0.0011	0.1520	1.0133±0.0006	0.1555

Note: NC stands for not calculated

\+ Arranged in order of increasing lattice spacing.

++ EALF is the energy of the average lethargy causing fission.

TABLE 9.1A-14 DATA FOR DECAY HEAT LOAD LIMIT EVALUATION

Length of Spent Fuel Pool (min.)	597.56 inch
Width of Spent Fuel Pool (min.)	339 inch
Pool Building Ambient Temperature	110°F
Emissivity of Water	0.96
Specific Heat of Water	0.998 Btu/(lb x °F)
HX Temperature Effectiveness	0.4981 (partial core) 0.3116 (full core)
Coolant Water Inlet Temperature	105°F 130°F (post LOCA)
Coolant Water Flow Rate	1.50×10^6 lb/hr (partial core) 0.75×10^6 lb/hr (post LOCA) 3.00×10^6 lb/hr (full core)

TABLE 9.1A-15 DATA FOR TIME-TO-BOIL EVALUATION

Length of Spent Fuel Pool	597.56 inch
Width of Spent Fuel Pool	339 inch
Depth of Spent Fuel Pool	37.25 ft
Total Fuel Rack Weight	411,320 lb
Number of Fuel Assemblies	2,642 assys
Bounding Assembly Weight	1,467 lb
Pool Building Ambient Temperature	110°F
Emissivity of Water	0.96
Pool Thermal Capacity	3.144×10^6 Btu/°F
Specific Heat of Water	0.998 Btu/(lb x°F)

TABLE 9.1A-16 DATA FOR LOCAL TEMPERATURE EVALUATION

Bounding Assembly Weight	1467 lb
Maximum Fuel Assembly Heat Flux	1870 Btu/hr-ft^2
Radial Peaking Factor	1.65
Total Peaking Factor	2.5
Number of Fuel Assemblies	2642
SFPCCS Water Flow Rate	3.0×10^6 lb/hr
Type of fuel assembly	Westinghouse 17x17 Std.
Fuel Rod Outer Diameter	0.374 in
Rack Cell Inner Dimension	8.77 in
Active Fuel Length	144
Number of Fuel Rods per Assembly*	289 rods
Rack Cell Length	169 in
Minimum Bottom Plenum Height	5 in

* Note: Fuel assembly is modeled as a square array with all locations containing fuel rods.

TABLE 9.1A-17 RESULTS OF DECAY HEAT LOAD LIMIT EVALUATION

Scenario	Number of SFPCCS Trains	Maximum Bulk Temperature	Maximum Decay Heat Load Limit (Btu/hr x 10^6)	Required Makeup Water Volume (gpm)
Partial- core offload	1	140°F (limit)	27.15	1.80
Full-core offload	1	170°F (calculated)	63.41	5.57

TABLE 9.1A-18 RACK MATERIAL DATA (200°F)

(ASME - Section II, Part D)			
Material	Young's Modulus E (psi)	Yield Strength S_y (psi)	Ultimate Strength Su (psi)
SA240; 304L S.S.	27.6×10^6	21,300	66,200
SUPPORT MATERIAL DATA (200°F)			
SA240, Type 304L (upper part of support feet)	27.6×10^6	21,300	66,200
SA-564-630 (lower part of support feet; age hardened at 1100°F)	28.5×10^6	106,300	140,000

TABLE 9.1A-19 TIME-HISTORY STATISTICAL CORRELATION RESULTS

OBE	
Data1 to Data2	0.0793
Data1 to Data3	0.0174
Data2 to Data3	0.0464
DBE	
Data1 to Data2	0.0061
Data1 to Data3	0.0127
Data2 to Data3	0.0874

Data1 corresponds to the time-history acceleration values along the X axis (North)

Data2 corresponds to the time-history acceleration values along the Y axis (West)

Data3 corresponds to the time-history acceleration values along the Z axis (Vertical)

TABLE 9.1A-20 COMPARISON OF BOUNDING CALCULATED LOADS/STRESSES VS. CODE ALLOWABLES AT IMPACT LOCATIONS AND AT WELDS

Item/Location	OBE		SSE	
	Calculated	Allowable	Calculated	Allowable
Fuel assembly/cell wall impact, lbf.	403	3,404^{+}	840	3,404
Rack/baseplate weld, psi	12,111	19,860	22,514	35,748
Female pedestal/baseplate weld, psi	8,099	19,860	21,617	35,748
Cell/cell welds, lbf.	1,140^{++}	3,195	2,546	5,751

\+ Based on the limit load for a cell wall. The allowable load on the fuel assembly may be less, but is greater than 840lbs

++ Based on the fuel assembly to cell wall impact load simultaneously applied in two orthogonal directions.

TABLE 9.1A-21 BENDING STRENGTH EVALUATION

Location	Limiting Safety Margin	Critical Load Combinations (see Section 9.1A.4.4.3.4)
CP + SFP East Wall	1.07	SC1 (12)
SFP West Wall	3.61	SC2 (13)
SFP North Wall	3.23	SC1 (12)
CP North + SFP South Wall	3.43	SC2 (13)
Cask Loading Pit West Wall	1.49	SC1 (13)
Cask Loading Pit South Wall	2.40	SC1 (13)

Note: SC1 corresponds to the condition SFP and CP full of water and SC2 corresponds to the condition SFP full and CP empty.

TABLE 9.1A-22 SHEAR STRENGTH EVALUATION

Location	Limiting Safety Margin	Critical Load Combinations (see Section 9.1A.4.4.3.4)
CP + SFP East Wall	1.05	SC1 (13)
SFP West Wall	2.27	SC2 (12)
SFP North Wall	1.05	SC1 (12)
CP North + SFP South Wall	1.05	SC2 (13)
Cask Loading Pit West Wall	1.57	SC1 (12)
Cask Loading Pit South Wall	1.26	SC1 (12)

Note: SC1 corresponds to the condition SFP and CP full of water and SC2 corresponds to the condition SFP full and CP empty.

9.2 WATER SYSTEMS

9.2.1 STATION SERVICE WATER SYSTEM

The station service water system consists of the service water system (SWS) and essential service water system (ESWS). In addition to the following description of the SWS and the ESWS, also refer to Section 9.2.1 of the Site Addendum.

9.2.1.1 Service Water System

The SWS is a nonsafety-related system which provides a source of heat rejection for plant auxiliaries which require cooling during normal plant operation and normal plant shutdown. The system also supplies cooling water to the safety-related ESWS during normal operation. The sources of cooling water for the SWS are described in Section 9.2.1 of the Site Addendum. The heated service water is discharged to the circulating water system.

9.2.1.1.1 Design Bases

9.2.1.1.1.1 Safety Design Bases

The SWS serves no safety-related function.

9.2.1.1.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - The SWS provides sufficient cooling water for the heat removal from nonessential auxiliary plant equipment and from the ESWS over the full range of the normal reactor operation and normal shutdown.

9.2.1.1.2 System Description

9.2.1.1.2.1 General Description

The SWS within the power block consists of piping, valves, and instrumentation, as shown in Figure 9.2-1. During normal plant operation, the SWS supplies cooling water to the turbine plant auxiliary equipment, steam generator blowdown nonregenerative heat exchanger, and CVCS chiller, as well as components served by the ESWS. The components cooled by the SWS and their nominal SWS flow rates and heat loads are given in Table 9.2-1.

Actual SW flow rates are maintained to ensure the design temperature and pressure of equipment is maintained. SW system flow rates will vary if the heat exchanger is fouled, tubes on the heat exchanger are plugged, SW temperature is less than 95°F or if heat load of equipment cooled is reduced.

9.2.1.1.2.2 Component Description

The SWS piping and valves are carbon steel and are designed to meet the requirements of ANSI B31.1. Valves EAV0001, EAV0004, EAV0006, EAV0008, EAV0043, EAV0184, EAV0185, EAV0186 and EAV0187 are stainless steel and meet ANSI B31.1. The design ratings of the SWS supply lines are 200 psig and 150°F, and discharge lines to the circulating water system are 85 psig and 150°F.

9.2.1.1.2.3 System Operation

Refer to the Site Addendum for operation of the pumps. Upon loss of offsite power or the receipt of an SIS, the system is isolated from the ESWS, as described in Section 9.2.1.2.

9.2.1.1.3 Safety Evaluation

The SWS has no safety-related functions.

9.2.1.1.4 Test and Inspection

Preoperational testing is described in Chapter 14.0. The performance and structural and leaktight integrity of all cooling water system components is demonstrated by continuous operation.

9.2.1.1.5 Instrumentation Applications

The SWS instrumentation is designed to facilitate automatic operation, remote control, and continuous indication of system parameters.

Local pressure and temperature indicators are provided at various components which are served by the SWS. Control valves are provided to control water flow where necessary.

9.2.1.2 Essential Service Water System

The ESWS removes heat from plant components which require cooling for safe shutdown of the reactor or following a DBA. The ESWS also provides emergency makeup to the spent fuel pool and component cooling water systems, and is the backup water supply to the auxiliary feedwater system. The ESWS consists of two redundant cooling water trains.

9.2.1.2.1 Design Bases

9.2.1.2.1.1 Safety Design Basis

The ESWS is safety related, is required to function following a DBA, and is required to achieve and maintain the plant in a safe shutdown condition.

SAFETY DESIGN BASIS ONE - The ESWS is protected from the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, and external missiles (GDC-2).

SAFETY DESIGN BASIS TWO - The ESWS is designed to remain functional after an SSE and to perform its intended function following the postulated hazards of fire, internal missile, or pipe break (GDC-3 and 4).

SAFETY DESIGN BASIS THREE - Safety functions can be performed, assuming a single active component failure coincident with the loss of offsite power (GDC-44). Components of this system are not shared with other units (GDC-5).

SAFETY DESIGN BASIS FOUR - The active components are capable of being tested during plant operation. Provisions are made to allow for inservice inspection of components at appropriate times specified in the ASME Boiler and Pressure Vessel Code, Section XI (GDC-45 and 46).

SAFETY DESIGN BASIS FIVE - The ESWS is designed and fabricated to codes consistent with the quality group classification assigned by Regulatory Guide 1.26 and the seismic category assigned by Regulatory Guide 1.29. The power supply and control functions are in accordance with Regulatory Guide 1.32.

SAFETY DESIGN BASIS SIX - The capability to isolate components or piping is provided so that the ESWS's safety function will not be compromised. This includes isolation of components to deal with leakage or malfunctions and to isolate nonsafety-related portions of the ESWS (GDC-44).

SAFETY DESIGN BASIS SEVEN - The containment isolation valves in the system are selected, tested, and located in accordance with the requirements of GDC-54 and 56 and 10 CFR 50, Appendix J, Type C testing.

SAFETY DESIGN BASIS EIGHT - The ESWS is designed to remove heat from components important to mitigating the consequences of a LOCA or MSLB and to transfer the heat to the ultimate heat sink (GDC-44).

SAFETY DESIGN BASIS NINE - The ESWS operates in conjunction with the component cooling water and other reactor auxiliary components and the ultimate heat sink to provide a means to cool the reactor core and RCS to achieve and maintain a safe shutdown.

SAFETY DESIGN BASIS TEN - The ESWS provides emergency makeup to the spent fuel pool and component cooling water systems, and is the backup water supply to the auxiliary feedwater system.

9.2.1.2.1.2 Power Generation Design Basis

POWER GENERATION DESIGN BASIS ONE - The ESWS provides sufficient cooling water for removing heat from essential plant equipment over the full range of the normal reactor operation.

9.2.1.2.2 System Description

9.2.1.2.2.1 General Description

The ESWS is shown in Figure 9.2-2 and consists of two separate 100-percent capacity trains of piping, valves, and instrumentation. The essential service water pumps, which are discussed in Section 9.2.1 of the Site Addendum, draw water from the ultimate heat sink at a maximum temperature of 92.3°F (see Safety Evaluation 8 in Section 9.2.1.2.3) and a minimum design temperature of 32°F. Each train of the ESWS serves through the associated train of safety-related components. Each train of the ESWS is interconnected with the SWS. Two motor-operated isolation valves are provided in each crosstie header where it connects to the SWS. In addition, cooling water flow is maintained following a DBA to a nonsafety-related air compressor and associated after-cooler in each train. The air compressor is automatically isolated on high flow (indicative of leakage) or it can be remote manually isolated.

The water chemistry of the ESWS fluid is given in Table 9.2-16. The metallic piping in the ESWS is designed with a corrosion tolerance to assure that there is no long-term degradation of the system. The components cooled by or supplied with makeup water from the ESWS and their respective heat loads and flow rates are given in Tables 9.2-2 through 9.2-4. The basis for the heat loads and flow rates is given in the referenced sections in Tables 9.2-2 through 9.2-4.

The minimum required flow to components served by the ESW system is controlled by plant procedures. The minimum flow rate is based on the following parameters:

1) The maximum ESW supply temperature

2) The heat load of the component or room

3) The process fluid flow rate

4) The effective surface area of the heat exchanger

5) The design fouling factors as defined by the heat exchanger data sheet or as provided by the heat exchanger manufacturer.

The ESWS normally supplies water at a higher pressure than the cooled safety-related component. Therefore, if leakage occurs it will be into the system being cooled or, in the

case of ESW piping and valves, in the floor drain system described in Section 9.3.3. Once a significant leak is found, an affected item will be isolated and repaired.

9.2.1.2.2.2 Component Description

Codes and standards applicable to the ESWS are listed in Table 3.2-1. The ESWS is designed and constructed in accordance with the following quality group requirements: Containment penetrations are quality group B, the separate and redundant cooling loops for safety-related equipment are quality group C, and lines to other nonessential equipment are quality group D. The quality group B and C portions are seismic Category I.

ESSENTIAL SERVICE WATER PUMPS - The two essential service water pumps each have a capacity of 100 percent of the flowrate required during normal operation. These designs exceed the required accident condition flowrate. Pumps are sized to include an additional wear margin on the flow at the design head to accommodate normal degradation of performance due to impeller wear. The ESW pumps, supporting systems, NPSH available, and flood protection are described in Section 9.2.1 of the Site Addendum.

AUXILIARY HEAT EXCHANGERS - Tables 9.2-2 through 9.2-4 list the various components in the ESWS and their nominal heat loads and flow requirements. In general, essential service water flows through the tube side, and the cooled fluid flows through the shell side. Further description of these items is included in the referenced sections.

PIPING AND VALVES - Piping within the standard power block to and from the ultimate heat sink is carbon steel, stainless steel, or polyethylene. The maximum design condition for supply water is 200 psig and 100°F, and the maximum design condition for the return line is 200 psig and 200°F. Certain piping segments have lower design pressures and temperatures based on maximum calculated operating conditions for these segments. Two entirely separate redundant lines are provided and designed to ASME Section III, Class 3, except for containment penetrations which are designed to ASME Section III, Class 2. Nonsafety-related portions of the system are designed to ANSI B31.1.

For the components located inside the containment, supply and return lines are provided with containment isolation valves, as described in Section 6.2.4.

Power-operated valves are provided to permit isolation of nonsafety-related or nonessential service following a DBA.

For a description of the yard piping outside of the standard power block, see Section 9.2.1 of the Site Addendum.

9.2.1.2.2.3 System Operation

POWER GENERATION OPERATION - During normal plant operations, the ESW within the standard power block receives water from the SWS and supplies water to the safety-related components and air compressors. After cooling the equipment, the heated water is returned to the SWS.

Manual bypass valves are provided around the motor operated valves on the ESW return line from the component cooling water heat exchangers. During normal operation, these valves are adjusted for proper flow for safety functions and locked into position, and the motor operated valves remain open. Motor-operated bypass isolation valves are also provided in outlet lines from the containment air coolers outside the containment. During normal plant operation, these bypass isolation valves remain open, and the main outlet isolation valves outside the containment remain closed.

The ESWS does not directly interface with radioactive systems. The only credible inleakage path of potentially contaminated water into the ESW system is contamination from the CCW heat exchanger if simultaneous leaks occurred between CCW and interfacing systems and in the CCW/ESW Heat Exchangers. The other components served by ESW system are room coolers, the diesel generator coolers and the Control Room and Class 1E refrigerant coolers. The CCW system is a clean system which cools potentially radioactive systems and components. This system has radioactivity monitors EG-RE-09 and EG-RE-10 to detect, indicate and alarm any inleakage into this system. To detect inleakage into the SW/ESW system periodic samples of the SW/ESW system will be analyzed. Analysis of SW/ESW for activity will be performed weekly when the Component Cooling Water and the Steam Generator Blowdown activity is less than the alarm setpoint of EG-RE-09, EG-RE-10, SJ-RE-02 and BM-RE-25. The sampling will be performed more frequently if radiation monitors EG-RE-09, EG-RE-10, SJ-RE-02 or BM-RE-25 reach the alarm setpoint.

The normal makeup water to the spent fuel pool and component cooling water system is from other plant sources, and the ESWS is only used if the other systems are unable to supply water.

PLANT COOLDOWN AND SHUTDOWN - No changes to the valving arrangement are required from the normal operation to initiate cooldown of the plant. During the cold shutdown condition, various components may be isolated if no heat loads are generated. The source of water is normally from the SWS; however, if offsite power is not available the Class 1E ESW pumps will provide the water source.

EMERGENCY OPERATION - Following a DBA or loss of offsite power, the safety-related signals will isolate the ESWS from the SWS by closing the associated motor-operated isolation valves. Also, the essential service water pumps will automatically start receiving power from the preferred power supply or the emergency diesel generators and supply water from the ultimate heat sink to the safety-related components and air compressors. The motor operated valves on the ESW return lines for the component

cooling water heat exchangers, and the main isolation valves for the containment air coolers are automatically positioned, to decrease and increase, respectively, the cooling water flow rate as dictated by the service requirements. After cooling the equipment, the heated water is returned to the ultimate heat sink. Motor-operated valves in the UHS cooling tower will open to allow flow to return to the UHS cooling pond. Following the loss of only one Class-1E 4160-V bus (not a design basis event), the ESWS will isolate from the service water system and the ESW pumps will automatically start as described above. The ESW pump and valves in the train of the lost bus will perform as though a complete loss of offsite power has occurred. The other ESW pump will start following signals which indicate both undervoltage on the opposite train bus and loss of flow to the containment coolers. Signals will also be given to open the inlet valve to the CCW heat exchanger and the return valve to the UHS in the train opposite that of the lost bus. The signal to start the opposite train ESW pump is isolated following a DBA or complete loss of offsite power. These signals preclude the need for operator action should only one Class-1E 4160-V bus be lost.

As described in Section 10.4.9, the ESWS, which is credited for accident mitigation, will automatically supply water to the auxiliary feedwater system in the event nonsafety-related condensate storage tank water is unavailable. In addition to the SIS and loss of offsite power signals, the ESW pump start logic includes the open signal to the ESW supply valve to the auxiliary feedwater system (AFS) on low suction pressure (LSP).

The auxiliary feedwater LSP signal also closes the ESW/SW system isolation valves located at the power block inlet. This assures ESW supply to the AFS following an SSE without an accompanying accident or loss of offsite power. During this event, the ultimate heat sink volume allows operator alignment of the ESW system to the UHS.

9.2.1.2.3 Safety Evaluation

Safety evaluations are numbered to correspond to the safety design bases.

SAFETY EVALUATION ONE - Except for the buried piping between the ESWS pumphouse, UHS Cooling Tower, ESW Supply Lines Yard Vault and the power block, the safety-related portions of the ESWS are located in the reactor, auxiliary, control, diesel, UHS Cooling Tower, ESW Supply Lines Yard Vault and essential service water pumphouse buildings. These buildings are designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other appropriate natural phenomena. Sections 3.3, 3.4, 3.5, 3.7(B), and 3.8 provide the bases for the adequacy of the structural design of these buildings. The buried piping is also designed to withstand these natural phenomena, as described in Section 9.2.1.2 of the Site Addendum.

SAFETY EVALUATION TWO - The safety-related portions of the ESWS are designed to remain functional after a SSE. Sections 3.7(B).2 and 3.9(B) provide the design loading conditions that were considered. Sections 3.5, 3.6, and 9.5.1 provide the hazards

analyses to assure that safe shutdown, as outlined in Section 7.4, can be achieved and maintained.

SAFETY EVALUATION THREE - The ESWS is completely redundant and, as indicated by Table 9.2-5 (which also addresses UHS cooling tower single failures), no single active failure will compromise the ESWS safety functions. All vital power can be supplied from either onsite or offsite power systems, as described in Chapter 8.0.

SAFETY EVALUATION FOUR - The ESWS is initially tested with the program given in Chapter 14.0. Periodic inservice functional testing is done in accordance with Section 9.2.1.2.4.

Section 6.6 provides the ASME Boiler and Pressure Vessel Code, Section XI requirements that are appropriate for the ESWS.

SAFETY EVALUATION FIVE - Section 3.2 delineates the quality group classification and seismic category applicable to the safety-related portion of this system and supporting systems. Section 9.2.1.2.2.2 shows that the components meet the design and fabrication codes given in Section 3.2. All the power supplies and the control function necessary for safe function of the ESWS are Class 1E, as described in Chapters 7.0 and 8.0.

SAFETY EVALUATION SIX - Section 9.2.1.2.2.1 describes provisions made to identify and isolate leakage or malfunction and to isolate the nonsafety-related portions of the system.

SAFETY EVALUATION SEVEN - Sections 6.2.4 and 6.2.6 provide the safety evaluation for the system containment isolation arrangement and testability.

SAFETY EVALUATION EIGHT - The nominal flow rates required to remove heat from the containment and necessary safety-related components from a postulated LOCA or MSLB and dissipate it to the ultimate heat sink are listed in Table 9.2-3. The ESWS design assures that the flow requirements are met by operation of an ESWS pump and proper realignment of the valves to the accident configuration. The design-basis maximum ESW supply temperature from the UHS retention pond is 95°F. That value was used in the design of the UHS cooling tower cells (FSAR Site Addendum Table 9.2-4 of Reference 1) and is the assumed ESW inlet temperature to all loads served by ESW except for the electrical penetration room coolers. However, the maximum ESW supply and UHS retention pond temperature of 92.3°F establishes the upper acceptance criterion in the minimum heat transfer and maximum evaporation cases in the analysis supporting the 30-day UHS inventory requirement per RG 1.27 (Ref. 2). In addition, an ESW inlet temperature of 92.3°F is also assumed in the analysis of the electrical penetration room temperatures (room coolers supplied by ESW). The 92.3°F value is the maximum temperature allowed in these analyses to support UHS operability assuming an initial maximum temperature of 89°F.

Each train of the ESWS and each train of the safety-related systems served by the ESWS are 100 percent redundant. This arrangement ensures that the full-heat dissipating capacity is available following an accident and an assumed single failure.

SAFETY EVALUATION NINE - The nominal ESWS flow rate required to remove decay heat from the RCS and other necessary components to achieve and maintain a safe shutdown under normal conditions is listed in Table 9.2-4. Safety Evaluation 8 discusses the ESW/UHS design basis temperature. The ESWS design assures that the flow requirements are met by operation of an ESWS pump and proper realignment of the valves to the accident configuration.

SAFETY EVALUATION TEN - The minimum ESWS flow rate required to provide emergency makeup to the spent fuel pool and component cooling water systems and the backup water to the auxiliary feedwater system is listed in Table 9.2-3. The ESWS design assures that the flow requirements are met by operation of an ESWS pump in each train and proper realignment of the associated valves.

9.2.1.2.4 Tests and Inspections

Preoperational testing is described in Chapter 14.0. The performance and structural and leaktight integrity of all cooling water system components is demonstrated by continuous operation.

The ESWS is testable through the full operational sequence that brings the system into operation for reactor shutdown and for LOCAs, including operation of applicable portions of the protection system and the transfer between normal and standby power sources.

The safety-related components of the ESWS, i.e., pumps, valves, heat exchangers, and piping (to the extent practicable), are designed and located to permit preservice and inservice inspections.

9.2.1.2.5 Instrumentation Applications

The ESWS instrumentation, as described on Table 9.2-6, is designed to facilitate automatic operation and remote control of the system and to provide continuous indication of system parameters. Redundant controls are provided to initiate the start of the ESWS and to isolate it from the SWS upon receipt of an SIS and/or loss of offsite power. Redundant and independent power supplies for pump controls and instrumentation are provided from Class 1E busses. Refer to Chapter 8.0.

Thermowells and pressure indicator connections are provided where required for testing and balancing the system. Portable ultrasonic flow indicators (and permanently installed flow indicators) are utilized for balancing of the flows in the system and for verifying flows during plant operation.

9.2.2 COOLING SYSTEM FOR REACTOR AUXILIARIES

The cooling system for the reactor auxiliaries is the component cooling water system (CCWS). The CCWS provides cooling water to selected auxiliary components during normal plant operation, including shutdown, and also provides cooling water to several engineered safety feature systems (ESFS) during a LOCA or MSLB. This system is a closed loop system which serves as an intermediate barrier between the SWS or ESWS and potentially radioactive systems in order to eliminate the possibility of an uncontrolled release of radioactivity.

9.2.2.1 Design Bases

9.2.2.1.1 Safety Design Basis

Portions of the CCWS are safety related and are required to function following a DBA and to achieve and maintain the plant in a safe shutdown condition.

SAFETY DESIGN BASIS ONE - The CCWS is protected from the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, and external missiles (GDC-2).

SAFETY DESIGN BASIS TWO - The CCWS is designed to remain functional after a SSE and to perform its intended function following the postulated hazards of fire, internal missile, or pipe break (GDC-3 and 4).

SAFETY DESIGN BASIS THREE - Safety functions can be performed, assuming a single active component failure coincident with the loss of offsite power (GDC-44).

SAFETY DESIGN BASIS FOUR - The active components are capable of being tested during plant operation. Provisions are made to allow for inservice inspection of components at appropriate times specified in the ASME Boiler and Pressure Vessel Code, Section XI (GDC-45 and 46).

SAFETY DESIGN BASIS FIVE - The CCWS is designed and fabricated to codes consistent with the quality group classification assigned by Regulatory Guide 1.26 and the seismic category assigned by Regulatory Guide 1.29. The power supply and control functions are in accordance with Regulatory Guide 1.32.

SAFETY DESIGN BASIS SIX - The capability to isolate components or piping is provided so that the CCWS's safety function will not be compromised. This includes isolation of components to deal with leakage or malfunctions and to isolate nonsafety-related portions of the system (GDC-44).

SAFETY DESIGN BASIS SEVEN - The containment isolation valves in the system are selected, tested, and located in accordance with the requirements of GDC-54 and 56 and 10 CFR 50, Appendix J, Type C testing.

SAFETY DESIGN BASIS EIGHT - The CCWS is designed to remove heat from components important to mitigating the consequences of a LOCA or MSLB and to transfer the heat to the essential service water system (GDC-44).

SAFETY DESIGN BASIS NINE - The CCWS, operating in conjunction with the RHR, chemical and volume control systems, and the water systems, provides a means to cool the reactor core and primary systems to achieve and maintain a safe shutdown.

9.2.2.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - The CCWS provides a continuous supply of cooling water during plant power generation operation to those auxiliary components in which the potential for radioactive leakage exists.

POWER GENERATION DESIGN BASIS TWO - The system is designed to allow for pump maintenance without interruption of the cooling function.

9.2.2.2 System Description

9.2.2.2.1 General Description

The CCWS is shown in Figure 9.2-3. The system consists essentially of two separate 100-percent-capacity trains which serve engineered safety features, and includes a loop, common to and isolatable from both trains, which serves the nonessential equipment.

The major components of the system are two component cooling water heat exchangers, four CCWS pumps, two surge tanks, a chemical addition tank, piping, valves, controls, and instruments. The components cooled by the CCWS and their respective CCWS heat loads and flow rates are given in Tables 9.2-7 through 9.2-9. The basis for the heat loads and flow rates is given in the appropriate section referenced in Tables 9.2-7 through 9.2-9.

9.2.2.2.2 Component Description

Codes and standards applicable to the CCWS are listed in Tables 3.2-1 and 9.2-10. The component cooling water system is designed and constructed in accordance with the following quality group requirements: Containment penetrations are quality group B, the separate and redundant cooling loops for engineered safety features equipment are quality group C, and lines to other equipment are quality groups C and D. The quality group B and C portions are seismic Category I.

COMPONENT COOLING WATER HEAT EXCHANGERS - Component cooling water heat exchangers are of the horizontal shell and straight tube type. The tube side is supplied with water from the service water or the ESWS, and the shell side is supplied with water from the discharge of the component cooling water pump. An overall heat transfer coefficient (UA) of 5.56×10^6 Btu/hr-F is assumed to conservatively calculate the

post-accident peak containment pressure and temperature. Section 6.2 provides the basis for the post-accident heat load.

COMPONENT COOLING WATER PUMPS - Each of the four component cooling water pumps has a capacity of 100 percent of the flowrate required during normal operation. This exceeds the required accident condition flowrate. The pumps are of the horizontal, centrifugal type. Pumps are sized to include an additional 5-percent margin on the flow at the design head to accommodate normal degradation of performance due to impeller wear.

Flooded suction is ensured by surge tanks. Each safety-related component cooling water train has two 100-percent capacity pumps. The two pumps in each component cooling water train are powered by the same Class 1E bus; however, only one pump per train is automatically started upon receipt of an SIS or loss of offsite power signal.

The installation of two 100-percent capacity pumps per train is provided only to avoid a shutdown which would otherwise be required by the technical specifications during prolonged maintenance or repair of a component cooling water pump.

SURGE TANKS - One safety-related component cooling water surge tank is provided in each of the two safety-related CCW trains to accommodate volumetric changes in the system due to thermal transients or leakage. Provisions are included for automatic makeup to the system from the demineralized water storage and transfer system.

CHEMICAL ADDITION TANK - One non-safety related CCWS chemical addition tank is provided with connections to both of the surge tanks. Provisions for demineralized makeup water and addition of the chemicals are included.

AUXILIARY HEAT EXCHANGERS - Tables 9.2-7 through 9.2-9 list the various components in the CCWS and their heat loads and flow requirements. In general, component cooling water flows through the shell side, and the potentially radioactive liquid flows through the tube side. Further description of these items is included in the referenced sections.

PIPING AND VALVES - Piping to and from the CCW heat exchangers is of carbon steel. The valves, which when open permit component cooling water to flow into or return from the nonsafety-related portion of the CCWS, are designed to fail closed. These valves automatically close upon low level in the surge tank or SIS. A flow orifice in the supply line to the radwaste service loads restricts flow to the non-safety related portion of the CCWS.

Component cooling water inlet valves to the RHR heat exchanger are motor operated and fail as is. These valves are remote manually opened prior to the post-LOCA recirculation phase.

For the components located inside the containment, supply and return lines are provided with containment isolation valves, as described in Section 6.2.4. For the reactor coolant pump thermal barriers, a separate return header arrangement is utilized to isolate primary coolant in-leakage to the component cooling water system in the event of a rupture in the thermal barrier. This header has its own containment penetration and automatic isolation valves. A CIS-B automatically closes the normally open motor-operated containment isolation valves. The normally closed (with power lockout) parallel sets of containment isolation valves will allow the operator to establish cooling water to the reactor coolant pumps and the excess letdown heat exchanger under emergency conditions, with a single failure.

A separate source of emergency makeup is provided from the ESWS to each train of the CCWS.

9.2.2.2.3 System Operation

GENERAL - The entire CCWS is a closed-cycle system; cooling water is continuously recirculated through the system by the CCWS pumps. Heat is dissipated from the system by the flow of service water or essential service water through the tube side of the component cooling water heat exchangers. A component cooling water heat exchanger shell side bypass arrangement maintains the minimum CCWS temperature at 40°F during cold service water conditions. The essential service water and service water systems are described in Section 9.2.1. Supply of normal makeup water to the system is provided from the demineralized water storage tank.

The water in the CCWS is analyzed periodically for pH, conductivity, and corrosion-inhibitor concentration. The specifications which apply to CCWS chemistry are given in Table 9.2-11. Abnormal chemistry is corrected by eliminating the source and by draining water from the system, as required, and adding makeup water to the surge tank. Periodic addition of water to the CCWS is required to make up for losses due to system leakage and sampling. For control of long-term corrosion, corrosion inhibitors are added, as required, via the chemical addition tank. The level indication on the surge tank and the rate of water addition will alert the operator of any abnormal leakage from the system. In addition, the floor drain system described in Section 9.3.3 provides additional detection capabilities. Once a significant leak is found, the affected item will be isolated and repaired.

Radiation monitors are installed to monitor the water in each CCWS train to indicate radioactivity leaking into the system. Alerted to radioactive inleakage, the operator may identify the leaking component by selective isolation of heat exchangers and determination of the rate of increase of CCW radioactivity at the component while the suspect component remains isolated. Once the source is determined, the component may remain isolated until repaired. A high radiation signal will automatically close the surge tank vent.

The excess letdown heat exchanger and the reactor coolant pump seal thermal barrier and motor bearing cooler are located inside the containment. Cooling is provided to the excess letdown heat exchanger for emergency cold shutdown operations. The chemical and volume control system injection path to the RCP seals is a totally diverse cooling means to the CCW supply. The reactor coolant pump motor bearings are qualified for 10 minutes of operation without cooling water. Pump operation can be terminated or the cooling water can be established within 10 minutes. The parallel-series valve arrangements for the containment penetrations ensure that CCW can be supplied to the containment, considering any single active failure. Redundant safety-related indication of CCW flow to components located inside the containment is provided on the MCB. A low flow alarm is also provided in the control room.

POWER GENERATION OPERATION - The system is normally operated with one pump on one of the safety-related CCWS trains supplying the associated safety-related and the nonsafety-related cooling water train. The redundant safety-related CCWS train is isolated from the remainder of the system, and the CCWS pumps in that train are not normally operated. Should an operating pump fail, a low-pressure switch in the pump discharge header will start the standby pump in the same train automatically after a 4-second delay. Also, an interlock is provided to start a CCWS pump when the corresponding ECCS centrifugal charging pump of the same train in the chemical and volume control system is started. During normal operation, the maximum CCWS supply water temperature to plant components will not exceed 105°F. Cooling water flow through the fuel pool cooling heat exchangers is normally required during periods when spent fuel is stored in the pool.

Heat absorbed by the CCWS is normally dissipated to the SWS.

PLANT COOLDOWN AND SHUTDOWN - During the plant cooldown phase following initiation of normal plant shutdown, if a 22.9-hour cooldown capability (to 140°F) is desired, both CCWS trains are placed in operation since flow through both RHR heat exchangers is required. An additional CCWS pump is started in the train which is supplying the other auxiliary loads, such as those associated with the chemical and volume control system, to assist in providing the necessary cooling flow. The plant may be brought safely to the cold shutdown condition with one RHR heat exchanger in operation, but this would require 33.6 hours to reach an RCS temperature of 200°F.

After initiation of CCWS flow to the RHR heat exchanger, (~4 hours after shutdown), CCWS equilibrium temperature at the CCWS heat exchanger outlet rises to 120°F. At this time, CCWS flow to the spent fuel pool heat exchanger may be terminated. Flow is normally resumed at 8 hours after shutdown when CCWS duty is lowered to accommodate the spent fuel pool load.

During periods of plant cold shutdown for maintenance or refueling operations following the plant cooldown phase, one of the trains of the CCWS may be shut down, and one of the RHR heat exchangers may be taken out of service. At least one CCWS pump and one RHR heat exchanger are required to be in operation during cold shutdown to remove

decay heat from the reactor coolant system. Cooling water flow through the fuel pool cooling heat exchangers is also required to cool spent fuel. In this mode of operation, heat absorbed by the CCWS is dissipated to the service water or essential service water system.

One train of CCW is capable of removing the decay heat during and immediately following a full core offload. During the full core offload, one CCW pump may provide flow to both the RHR heat exchanger and the spent fuel pool cooling heat exchanger. As bulk fuel storage pool temperature increases during or immediately after a full core offload, CCW flow can be increased to accommodate the increased spent fuel pool heat exchanger load (RHR heat exchanger duty decreases). If necessary, two CCW pumps in one train can provide the analyzed flow rate (3.0 x 10^6 lbm/hr) for the full core offload case (see Table 9.1-4).

EMERGENCY OPERATION - Upon receipt of a safety injection signal (SIS), the isolation valves for the nonseismic Category I CCWS loop are closed automatically, and one of the pumps in the nonoperating, safety-related CCWS train is started. Component cooling water flows through normally open valves to the seal coolers for the residual heat removal pumps and to the oil coolers for the ECCS centrifugal charging pumps and safety injection pumps. Upon a loss of offsite power, any operating CCWS pump stops, and two pumps, one in each train, start in accordance with the standby diesel generator loading sequence (see Chapter 8.0).

Prior to the initiation of the recirculation phase, operator action is required to realign the system. Cooling water flow is initiated through the residual heat removal heat exchangers by completely opening the normally throttled, motor-operated valves at the inlets to the heat exchangers and closing outlet valves associated with the spent fuel pool heat exchanger. This establishes a cooling water flow to remove heat from the containment sump water which is flowing through the residual heat removal system. After approximately 4 hours, the flow may be resumed to the spent fuel pool heat exchanger.

The complete switchover sequence is described in Section 6.3. In the emergency mode of operation, the two cooling trains are normally operated in a parallel configuration. Remotely operated isolation valves are provided to permit complete separation of the two trains.

In the event that an emergency cold shutdown (CSD) must be achieved using only safety-related systems and components, the CCW system can withstand a single active failure and still remove heat from components important to achieving and maintaining a safe shutdown. These components include the reactor coolant pump thermal barrier and motor bearings, seal water return heat exchanger, excess letdown heat exchanger, RHR heat exchanger, and spent fuel pool cooling heat exchanger.

9.2.2.3 Safety Evaluation

Safety evaluations are numbered to correspond to the safety design bases in Section 9.2.2.1.

SAFETY EVALUATION ONE - The safety-related portions of the CCWS are located in the reactor, auxiliary, and fuel buildings. These buildings are designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other appropriate natural phenomena. Sections 3.3, 3.4, 3.5, 3.7(B), and 3.8 provide the bases for the adequacy of the structural design of these buildings.

SAFETY EVALUATION TWO - The safety-related portions of the CCW system are designed to remain functional after a SSE. Sections 3.7(B).2 and 3.9(B) provide the design loading conditions that were considered. Sections 3.5, 3.6, and 9.5.1 provide the hazards analyses to assure that a safe shutdown, as outlined in Section 7.4, can be achieved and maintained.

SAFETY EVALUATION THREE - The CCWS is completely redundant and, as indicated by Table 9.2-12, no single failure will compromise the system's safety functions. All vital power can be supplied from either onsite or offsite power systems, as described in Chapter 8.0.

SAFETY EVALUATION FOUR - The CCWS is initially tested with the program given in Chapter 14.0. Periodic inservice functional testing is done in accordance with Section 9.2.2.4.

Section 6.6 provides the ASME Boiler and Pressure Vessel Code, Section XI requirements that are appropriate for the CCW system.

SAFETY EVALUATION FIVE - Section 3.2 delineates the quality group classification and seismic category applicable to the safety-related portion of this system and supporting systems. Table 9.2-10 shows that the components meet the design and fabrication codes given in Section 3.2. All the power supplies and control functions necessary for safe function of the CCW system are Class 1E, as described in Chapters 7.0 and 8.0.

SAFETY EVALUATION SIX - Section 9.2.2.2 describes provisions made to identify and isolate leakage or malfunction and to isolate the nonsafety-related portions of the system.

SAFETY EVALUATION SEVEN - Sections 6.2.4 and 6.2.6 provide the safety evaluation for the system containment isolation arrangement and testability.

SAFETY EVALUATION EIGHT - The nominal component cooling water flow rates required to remove heat from the reactor coolant system during and after a postulated LOCA are listed in Table 9.2-9.

The CCWS design assures that at least these nominal flows are achieved by the system in its accident configuration, i.e., one pump per train in operation and the nonseismic Category I CCW loop isolated. The system is shifted into the accident configuration upon receipt of an SIS signal which starts a pump in each train and isolates the nonessential flow paths. The CCWS flow to the RHR heat exchanger is initiated as the RHR heat exchanger (primary side) is placed in service prior to shifting to the recirculation mode. The CCWS heat is dissipated to the ESWS, as discussed in Section 9.2.1. The CCWS and each of the safety-related systems served by the CCWS are 100-percent redundant. This arrangement ensures that full-heat dissipating capacity is available following a LOCA and an assumed single failure.

SAFETY EVALUATION NINE - The nominal CCWS flow rates required to remove decay heat from the RCS during and following achieving a safe shutdown are listed in Table 9.2-8. Flow instrumentation indications and alarms are identified in Table 9.2-13. The CCWS heat is dissipated to the ESWS or SWS, as discussed in Section 9.2.1. The CCWS design assures that the flow requirements are met by operation of a CCWS pump and proper realignment of the associated valves.

9.2.2.4 Tests and Inspections

Preoperational testing is described in Chapter 14.0. The performance and structural and leaktight integrity of all component cooling water system components is demonstrated by continuous operation.

The CCWS is testable through the full operational sequence that brings the system into operation for reactor shutdown and for LOCAs, including operation of applicable portions of the protection system and the transfer between normal and standby power sources.

The safety-related components of the CCWS, i.e., pumps, valves, heat exchangers, and piping (to the extent practicable) are designed and located to permit preservice and inservice inspections.

9.2.2.5 Instrumentation Applications

The CCWS instrumentation is designed to facilitate automatic operation and remote control of the system and to provide continuous indication of system parameters.

High flow switches (BBFS0017, 0018, 0019, 0020) in the return lines from each reactor coolant pump thermal barrier cooling coil will initiate the rapid closure of isolation valves (BBHV0013, 0014, 0015, 0016) to isolate the applicable reactor coolant pump in the event of a leak in the thermal barrier.

Control room indication of surge tank levels keeps the operator informed of any leakage into or out of the CCWS. Actuation of the surge tank makeup valves is automatically initiated by the low level switch. The low-low level switch will automatically isolate the nonseismic Category I part of the nonsafety-related train from the system.

A radiation detection system is provided in each CCWS train to alarm abnormally high radioactivity which would be indicative of inleakage from one of the components. High radiation will isolate the CCWS surge tank vent in the affected flow train to prevent escape of radioactivity prior to isolation of the leak.

Thermowells and pressure indicator connections are provided where required for testing and balancing the system. Flow indicator taps are provided at strategic points in the system for initial balancing of the flows in the system and for verifying flows during plant operation.

Table 9.2-13 summarizes CCWS alarms and indications of status, temperature, flow, etc.

9.2.3 DEMINERALIZED WATER MAKEUP SYSTEM

The demineralized water storage and transfer system (DWSTS) stores water for use upon demand for makeup within the plant. The DWSTS receives filtered and demineralized water from the demineralized water makeup system (DWMS) (refer to Section 9.2.3 of the Site Addendum). For reactor makeup water, a degasifier removes oxygen from the demineralized water as it is transferred. The effluent from several systems which process waste, which can be recycled within the plant, are passed through the DWSTS degasifier before being transferred to the reactor makeup water storage tank (RMWST).

9.2.3.1 Design Bases

9.2.3.1.1 Safety Design Bases

The DWSTS serves no safety function and has no safety design basis.

9.2.3.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - The DWSTS and DWMS maintain chemistry specifications required by the plant components.

POWER GENERATION DESIGN BASIS TWO - The DWSTS provides demineralized water to the equipment and systems shown in Table 9.2-14.

POWER GENERATION DESIGN BASIS THREE - The DWSTS's capacity is sufficient to supply the anticipated normal makeup demand in any 24-hour period.

POWER GENERATION DESIGN BASIS FOUR - The demineralized water storage tank (DWST) has sufficient storage capacity to augment the condensate and reactor makeup water storage facilities so that a 3-day supply of normal anticipated makeup demand to both the secondary and the primary systems is maintained.

POWER GENERATION DESIGN BASIS FIVE - The DWSTS degasifies selected processed in-plant liquid waste and supplies it to the reactor makeup system with less than 0.1 ppm dissolved oxygen.

9.2.3.2 System Description

9.2.3.2.1 General Description

The DWSTS is shown in Figure 9.2-4. The system consists of one demineralized water storage tank, two 100-percent system capacity transfer pumps (connected in parallel), one degasifier, and associated piping, valves, controls, and instrumentation.

The DWMS which supplies the DWSTS is described in Section 9.2.3 of the Site Addendum. Redundant check valves are provided to preclude backflow from the DWSTS to the DWMS, assuring that contamination of the source is precluded. The provision for waste processing of regenerative waste in the DWMS is located outside of the power block and is described in Section 9.2.3 of the Site Addendum.

Samples may be taken from the discharge of the demineralized water transfer pumps. Chemical specifications for the demineralized water are given in Table 9.2-15 for the services indicated in Table 9.2-14.

9.2.3.2.2 Component Description

The DWSTS is designed and constructed in accordance with quality group D specifications.

DEMINERALIZED WATER STORAGE TANK - The demineralized water storage tank is a covered, vented, and insulated tank constructed of stainless steel and located outdoors. Freeze protection is provided by external steam heating coils and tank insulation. The capacity of the tank is 50,000 gallons.

DEMINERALIZED WATER TRANSFER PUMPS - The pumps are constant speed, electric motor-driven, vertical, centrifugal pumps. All parts in contact with the pumped fluid are stainless steel. The two pumps are connected in parallel with common suction and discharge lines.

DEGASIFIER - The degasifier consists of a level control valve, degasifier tank with integral 300-gallon storage section, two 100-percent system capacity, degasified water transfer pumps, and two 100-percent design capacity vacuum pumps. All parts in contact with the demineralized water are stainless steel, with the exception of the piping which is saran-lined and the degasifier column packing which is polypropylene.

9.2.3.2.3 System Operation

The flow of demineralized water to the demineralized water storage tank is controlled by an outlet valve which opens or closes due to tank level by the actuation of tank level switches. When the outlet valve is open, flow is varied proportionally to tank level by modulating the makeup demineralizer flow control valves located upstream of the outlet valve. (Site Addenda Section 9.2.3). Low-low level switches trip both the demineralized water transfer pumps and the condensate demineralizer sluice water pumps (Section 10.4.6.2.2) to prevent loss of suction. High and low tank level alarms are provided in the main control room. Tank level indication is provided in the main control room. The tank can be bypassed, if necessary.

The level indication read in the control room on the DWST and an imbalance of water addition versus controlled water discharge will indicate any abnormal leakage from the system. In addition, the floor drain system described in Section 9.3.3 provides additional detection capabilities.

The reactor makeup water system (described in Section 9.2.7) must receive deaerated water to meet the chemistry specifications. Aerated plant waste streams which are recycled must pass through the degasifier. The DWST can be used as a source of makeup to the primary side water inventory once the other sources are exhausted.

The flowrate of water to the degasifier is automatically controlled by the throttling of the inlet control valve in proportion to the degasifier column level. Degasification is accomplished by the spraying of the degasifier influent over the column packing while the column is maintained under vacuum. Vacuum is maintained by one of two centrifugal, oilsealed vacuum pumps. Alternately, vacuum may be maintained by means of the condenser vacuum pumps via a cross-connect line. The vacuum pump exhaust is combined with the exhaust of the condenser air removal system so that it will be discharged directly to the unit vent. Two 100-percent system capacity degasified water transfer pumps supply the reactor makeup water system on a demand basis.

9.2.3.3 <u>Safety Evaluation</u>

The DWSTS serves no safety-related function.

9.2.3.4 <u>Tests and Inspections</u>

Preoperational testing is described in Chapter 14.0.

The operability, performance, structural, and leaktight integrity of all system components is demonstrated by continuous operation.

9.2.3.5 Instrumentation Applications

Control room indication of DWST level is provided. Each pump discharge contains a pressure gauge. A local pressure gauge and control room low pressure alarm are provided for the demineralized water transfer pump header. The low pressure switch does not start the standby pump. The degasifier tank has a level gauge and local and control room high and low level alarms.

9.2.4 POTABLE AND SANITARY WATER SYSTEM

The domestic water system (DoWS) provides chlorinated potable water for drinking and cooking, and for showers, laundry, and toilet facilities within the standardized power block. Refer to Section 9.2.4 of the Site Addendum for the system in use outside the power block. Refer to Section 9.3.3 for the sanitary water system.

9.2.4.1 Design Bases

9.2.4.1.1 Safety Design Bases

The DoWS serves no safety function and has no safety design basis.

9.2.4.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - A chlorinated, pressurized source is provided to adequately meet the requirements of all outlets.

POWER GENERATION DESIGN BASIS TWO - The DoWS is designed so that there are no interconnections with systems which might contain radioactivity. In addition, the branches with outlets in areas where a radioactive hazard exists are designed with backflow-prevention capability to ensure that radioactive contamination cannot enter the system.

9.2.4.2 System Description

9.2.4.2.1 General Description

The DoWS is shown in Figure 9.2-5. The system consists of hot water storage heaters and the necessary interconnecting valves and piping. The treated water supply is provided from outside the power block, as described in Section 9.2.4 of the Site Addendum. Potable water is delivered to all points in the plant by way of the domestic water distribution piping system.

The system is designed to provide quantities of water adequate to enable proper functioning of the plumbing fixtures in all parts of the plant.

No cross connections exist between the DoWS and any radioactive or potentially radioactive system. Backflow prevention is provided for those branches with outlets in areas where a potential radiological hazard may occur, by providing minimum air gaps allowed by the Wisconsin Administrative Code. In addition, the main header serving these areas is provided with a reduced pressure backflow preventer device. Hot water supply and recirculation lines connected to the main hot water storage heater do not serve such areas.

Protection against pollution from any equipment which takes water from the DoWS but uses this water for purposes other than drinking, cooking, or washing is provided by passing the flow supplying such equipment through air gaps or a backflow prevention device of the reduced-pressure zone type.

Section 3.6 provides an evaluation demonstrating that pipe routing of the DoWS is physically separate from essential systems, to the maximum extent practicable. In addition, the floor drain system described in Section 9.3.3 provides leakage detection capabilities to assure that any abnormal leakage is detected and repaired.

9.2.4.2.2 Deleted

9.2.4.2.3 System Operation

The domestic water system is supplied by a pressurized, chlorinated potable water source, as described in Section 9.2.4 of the Site Addendum. The DoWS will automatically supply water when an intermittent demand is created at an outlet.

9.2.4.3 Deleted

9.2.4.4 Tests and Inspections

Preoperational testing is discussed in Chapter 14.0. Proper operation of the various components is verified by satisfactory use.

9.2.4.5 Deleted

9.2.5 ULTIMATE HEAT SINK

A description of the ultimate heat sink (UHS), including drawings for the site, is given in Section 9.2.5 of the Site Addendum. Evaluations of the UHS are presented in the Site Addendum.

9.2.5.1 Design Bases

9.2.5.1.1 Safety Design Basis

SAFETY DESIGN BASIS ONE - The UHS provides a reliable source of cooling water to achieve and maintain a safe shutdown of the reactor following a DBA (GDC-44).

SAFETY DESIGN BASIS TWO - The UHS supplies emergency makeup water to the spent fuel pool and component cooling water systems, and is the backup water supply for the auxiliary feedwater system.

9.2.5.1.2 Power Generation Design Basis

The UHS is not required for power generation.

9.2.5.2 System Description

9.2.5.2.1 General Description

The UHS consists of one seismic Category I mechanical draft cooling tower with redundant cells and a seismic Category I excavated retention pond.

UHS cooling water chemistry analysis is provided for information in Table 9.2-16.

9.2.5.2.2 Nominal Heat Loads

Integrated heat rejected to the UHS for up to 30 days after a DBA and normal shutdown using the UHS are provided in Figures 9.2-7(a), 9.2-7(b), and 9.2-9 which are compiled by summing contributions from the following sources:

a. Containment air coolers

b. Residual heat removal system

c. Station auxiliary systems

d. Spent fuel pool

Tabulated below are the nominal heat rejection rates for the specified time intervals, taken from Figures 9.2-6(e), 9.2-6(f), and 9.2-8.

	Normal Shutdown Using UHS (10^6 Btu/hr)	LOCA-Maximum Evaporation Case (10^6 Btu/hr)	LOCA-Minimum Heat Transfer Case (10^6 Btu/hr)
0 to 1 hour	24	448	502
1 to 10 hours	265	192	192
10 hours to 1 day	152	105	105
1 day to 3 days	94	81.3	80.8
3 days to 15 days	67	57.4	57.4
15 days to 30 days	36	45.2	45.2

9.2.5.2.2.1 Nominal Heat Loads Following a LOCA

The total integrated heat load for the 30-day period is conservatively calculated to be 54.9 x 10^9 Btu for the minimum heat transfer case shown on Figure 9.2-7(b). Based upon this value, the average heat load per unit during the 30 days following a LOCA is 76.3 x 10^6 Btu/hr.

Section 6.2.1 provides a detailed analysis of heat released to the containment following an accident. This analysis considers the heat rejection due to the stored thermal energy of the reactor coolant system and due to the heavy elements and fission products decay heat.

Figures 9.2-6(a) through 9.2-6(f), 9.2-7(a), and 9.2-7(b) depict the heat loads utilized to determine the thermal response of the UHS to heat loads following a LOCA with the assumed failure to close of one UHS cooling tower bypass valve. These figures conservatively represent heat rejection from all sources, including heat from the stored thermal energy of the reactor coolant system, fission product and heavy element decay, heat from the station auxiliary systems, and heat due to pump work. The heat rates and total integrated heat load shown in these figures are in accordance with Regulatory Guide 1.27 and provide additional conservatism over the heat rejected to containment as described in Section 6.2.1. These heat loads are based upon the following operational assumptions:

a. Operator action is taken within 70 minutes of large break LOCA initiation to diagnose and mitigate a postulated single failure of a UHS cooling tower bypass valve to close based on indications from NG07 and NG08 bus

voltage annunciators and proper equipment status (bypass valve position, UHS cooling tower fan speed) for the prevailing ESW return (UHS inlet) temperature.

b. Operator action is taken within 4 hours of large break LOCA initiation to use EFHS0067 (‘A’ train) and EFHS0068 (‘B’ train) to switch the temperature control circuitry for the automatic positioning of the UHS cooling tower bypass valves and UHS cooling tower fans (fans transition from off to slow speed then to high speed as temperature increases) from the ESW return temperature loops (UHS inlet) to the ESW pump discharge (ESW supply) temperature loops.

c. Two ESW trains may be in operation for up to 7 days after large break LOCA initiation. Within 7 days one ESW train is secured by operator action.

d. One ESW train is in operation for the remainder of the 30 days.

Table 9.2-5 (items 10 and 11) also identifies operator action that may be required to mitigate a postulated failure in the circuitry used to control the UHS cooling tower bypass valves and cooling tower fans based on ESW pump discharge (ESW supply) temperature.

The decay heat due to the heavy elements and fission products is calculated using ANSI/ ANS-5.1-1979.

The average nominal heat rejection rate of the station auxiliary systems listed in Table 9.2-17 following a LOCA is 17.86 x 10^6 Btu/hr. The total integrated heat released by the station auxiliaries for 30 days is conservatively calculated to be 1.29 x 10^{10} Btu. Section 9.1.3 describes the heat load from the spent fuel pool cooling system.

9.2.5.2.2.2 Nominal Heat Loads Following Normal Shutdown Using UHS

Figures 9.2-8 and 9.2-9 provide the heat loads as a function of time for a normal plant cooldown. The average heat load per unit during the 30 days following a normal plant cooldown is 55.7 x 10^6 Btu/hr. The total integrated heat load for the 30-day period is 40.1 x 10^9 Btu.

Heat rejected to the UHS following a normal shutdown is based on a decay heat generation rate of 78.9 x 10^6 Btu/hr at 20 hours following reactor shutdown. Refer to Section 5.4.7.2.1 for additional discussion.

The heat rejection rate of the station auxiliary systems listed in Table 9.2-18 is 15.09 x 10^6 Btu/hr. The total integrated heat released by the station auxiliaries for 30 days is 2.7 x 10^9 Btu.

The heat load from the spent fuel pool cooling system is described in Section 9.1.3.

As indicated by the above heat load values, normal shutdown heat loads are bounded by the LOCA heat loads.

9.2.5.2.3 Emergency Makeup Water Requirement

Power block emergency makeup water requirements are given in Figures 9.2-10 and 9.2-11.

The makeup water from the ESWS is required to supply the auxiliary feedwater system when the non-safety related condensate storage tank is unavailable or exhausted, as described in Section 10.4.9.

Makeup water from the ESWS is required to replace evaporative losses from the spent fuel pool, as described in Section 9.1.3. Makeup water may also be required to replace evaporative losses or minor leakage from the component cooling water system. Normal makeup is provided from other sources.

9.2.5.2.4 Component Description

Refer to Section 9.2.5.2 of the Site Addendum.

9.2.5.2.5 System Operation

Refer to Section 9.2.5 of the Site Addendum.

9.2.5.3 <u>Safety Evaluation</u>

SAFETY EVALUATION ONE - The UHS is capable of providing enough cooling water for a safe shutdown and for continued cooling of the reactor for 30 days following an accident.

The design basis heat load for the UHS is tabulated in Section 9.2.5.2.2. Section 9.2.5 of the Site Addendum provides a safety evaluation which demonstrates that the UHS capacity is sufficient for a 30-day supply of cooling water with supply temperature no greater then 92.3°F, assuming maximum engineered safety feature operation with minimum heat transfer conditions, as described in Section 9.2.5 of the Site Addendum. The maximum UHS retention pond temperature reached in the DBA during these conditions is 92.3°F. This is based on maximum heat load and the most severe meteorological conditions, as described in Section 9.2.5 of the Site Addendum. The

design-basis maximum ESW supply temperature from the UHS retention pond is 95°F. That value was used in the design of the UHS cooling tower cells (FSAR Site Addendum Table 9.2-4 of Reference 1) and is the assumed ESW inlet temperature to all loads served by ESW except for the electrical penetration room coolers. However, the maximum ESW supply and UHS retention pond temperature of 92.3°F establishes the upper acceptance criterion in the minimum heat transfer and maximum evaporation cases in the analysis supporting the 30-day UHS inventory requirement per RG 1.27 (Ref. 2). In addition, an ESW inlet temperature of 92.3°F is also assumed in the analysis of the electrical penetration room temperatures (room coolers supplied by ESW). The 92.3°F value is the maximum temperature allowed in these analyses to support UHS operability assuming an initial maximum temperature of 89°F.

SAFETY EVALUATION TWO - The minimum UHS reserve requirement to provide emergency makeup water to the spent fuel pool and component cooling water systems and backup water to the auxiliary feedwater system is provided in Figures 9.2-10 and 9.2-11. Section 9.2.5 of the Site Addendum provides the safety evaluation which demonstrates that the UHS has an adequate capacity to meet these needs.

9.2.5.4 Tests and Inspections

Refer to Section 9.2.5 of the Site Addendum.

9.2.5.5 Instrument Application

Refer to Section 9.2.5 of the Site Addendum.

9.2.6 CONDENSATE STORAGE AND TRANSFER SYSTEM

The condensate storage and transfer system (CSTS) consists of one 450,000-gallon condensate storage tank (CST), one 500,000-gallon hardened condensate storage tank (HCST), a non-safety auxiliary feedwater pump, and associated valves and piping. The CST serves as a reservoir to supply or receive condensate, as required by the condenser hotwell level control system. The CST is a nonseismically designed source of water to the auxiliary feedwater system and is not credited for accident mitigation. The HCST serves as an alternate supply of condensate to the auxiliary feedwater system. The HCST is seismically designed but is not credited for accident mitigation.

9.2.6.1 Design Bases

9.2.6.1.1 Safety Design Bases

The CSTS serves no safety function and has no safety design basis.

9.2.6.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - The minimum usable volume of the CST provides sufficient water to the suction of the auxiliary feedwater pumps for decay heat removal during a 4 hour Station Blackout event, as discussed in Table 8.3A-1, item III.A.

POWER GENERATION DESIGN BASIS TWO - CSTS permits periodic testing of the auxiliary feedwater pumps.

POWER GENERATION DESIGN BASIS THREE - The gross capacity of the CST is sufficient to fill the condensate system, feedwater system, and the steam generators.

POWER GENERATION DESIGN BASIS FOUR - The CSTS is designed to limit the dissolved oxygen in the CST to less than 0.1 ppm.

9.2.6.2 System Description

9.2.6.2.1 General Description

The CSTS is shown in Figure 9.2-12. The system consists of one CST, one HCST, non-safety auxiliary feedwater pump, and associated piping, valves, controls, and instrumentation. Section 3.6 provides an evaluation that demonstrates that the pipe routing of the CSTS is physically separated from the essential systems to the maximum extent practicable. Protection mechanisms that may be required are also discussed in Section 3.6.

A sample is periodically taken from the makeup line to the condenser hotwell for analysis to assure that the quality of the water stored in the CST meets the chemical specifications given in Table 9.2-15 for the services indicated in Table 9.2-19. Similarly, a sample is periodically taken from a sample line off the bottom of the HCST to assure the quality of the water stored in the HCST meets the chemical specifications given in Table 9.2-15.

9.2.6.2.2 Component Description

Codes and standards applicable to the CSTS are listed in Table 3.2-1. The system is designed and constructed in accordance with quality group D specifications.

CONDENSATE STORAGE TANK - The CST is a covered, insulated tank constructed of stainless steel. It is not a seismic Category I tank and is nonsafety-related. The tank has a fixed roof. The tank is located outdoors. Freeze protection is provided by thermal insulation and external steam heating coils. The capacity of the tank is 450,000 gallons.

HARDENED CONDENSATE STORAGE TANK - The HCST is a covered, insulated tank constructed of stainless steel. It is seismically designed but is classified as non-safety related. The tank has a floating roof. The tank is located outdoors. Freeze protection is

provided by thermal insulation and internal electric heaters. The capacity of the tank is 500,000 gallons.

NON-SAFETY AUXILIARY FEEDWATER PUMP - One non-safety-related motor-driven auxiliary feedwater pump (NSAFP) is driven by an ac-powered electric motor supplied with power from the alternate emergency power system (AEPS). The horizontal centrifugal pump takes suction from the non-safety related condensate storage tank (CST) and discharges to discharge piping of the turbine-driven auxiliary feedwater pump. Pump design capacity includes manually controlled minimum flow recirculation back to the CST. Refer to Table 9.2-22 for design data.

9.2.6.2.3 System Operation

The supply of demineralized water makeup to the CST is automatically controlled by the tank level. Low and high tank level signals cycle a control valve in the line from the demineralized water makeup system. High, low, and low-low tank level alarms are provided in the main control room. Tank level indication is provided in the main control room.

The level indication of the CST and an imbalance of water addition versus controlled water discharge will alert the operator of any abnormal leakage from the system. In addition, the floor drain system described in Section 9.3.3 provides additional detection capabilities. Section 3.6 demonstrates that a storage tank failure would have no detrimental effect on safety-related structures or equipment.

Deaeration of the CST during initial startup operations can be accomplished via the main condenser. The tank contents circulate to the deaerating hotwell of the condenser and are pumped back to the CST by a condensate pump. At low plant loads and at startup, the condenser spargers aid in the deaeration process. Deaeration is normally accomplished via a nitrogen purge supplied by the low pressure nitrogen portion of the Service Gas System.

Overflow of the CST is directed to the secondary liquid waste system, as described in Section 9.3.3. Isolation valves are provided for all lines which penetrate the tank, with the exception of the overflow. The minimum volume required for auxiliary feedwater is described in Section 8.3A.5.1.

The supply of demineralized water makeup to the HCST is manually controlled. Local tank level indication is provided inside the HCST valve house. Overflow of the HCST is directed to the secondary liquid waste system. Isolation valves are provided for all lines which penetrate the tank, with the exception of the overflow.

During normal operation, the CSTS contains no radioactive contaminants. In the event of primary-to-secondary system leakage due to a steam generator tube leak, it is possible for the CST contents to become radioactively contaminated. A discussion of the radiological aspects of primary-to-secondary leakage is included in Chapter 11.0.

When the auxiliary feedwater system (AFS) is started, the non-safety related condensate storage tank provides a clean source to feed to the steam generators. Upon low auxiliary feedwater pump suction pressure due to reduced level in the CST, the non-safety related HCST will automatically align to the AFS (via non-safety instrumentation) to provide another clean source to feed to the steam generators. If during emergency operation the CST and HCST are unavailable or exhausted, emergency backup water is automatically supplied from the essential service water system, as described in Section 10.4.9. The HCST will align to the AFS prior to the ESW swap-over during accident conditions and an extended loss of AC power (ELAP). The existing safety-related low suction pressure (LSP) signal that swaps the AFW suction line from the CST to the ESW system remains the credited accident mitigation strategy for design basis accidents. The HCST is not credited for accident mitigation.

The function of the non-safety auxiliary feedwater pump (NSAFP) is to provide an alternate source of cooling water to the steam generators through the Auxiliary Feedwater System. The NSAFP will be manually aligned upon the following events occurring simultaneously; loss of offsite power, loss of onsite power, and failure of the turbine-driven auxiliary feedwater pump.

9.2.6.3 Safety Evaluation

The CSTS serves no safety-related function.

9.2.6.4 Tests and Inspections

Preoperational testing is described in Chapter 14.0. The performance, structural, and leaktight integrity of all system components is demonstrated by continuous operation.

9.2.6.5 Instrumentation Applications

Control room indication of CST level is provided. Minimum tank temperature of 50°F is maintained automatically by steam heating coils to which steam is supplied in response to actual tank temperature.

Local indication of HCST level and temperature is provided. Minimum tank temperature of 50°F is maintained automatically by electric immersion heating coils to which power is supplied in response to actual tank temperature.

9.2.7 REACTOR MAKEUP WATER SYSTEM

The reactor makeup water system (RMWS) stores deaerated water to be used upon demand for primary makeup within the plant. The RMWS receives filtered, deaerated, demineralized water from the demineralized water storage and transfer system and from several systems which process waste water which can be recycled within the plant.

9.2.7.1 Design Bases

9.2.7.1.1 Safety Design Bases

Except for an associated containment penetration, the RMWS is not a safety-related system.

SAFETY DESIGN BASIS ONE - The containment isolation valves in the system are selected, tested, and located in accordance with the requirements of 10 CFR 50, Appendix A, General Design Criteria 54 and 56, and 10 CFR 50, Appendix J, Type C Testing.

9.2.7.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - The reactor makeup water storage tank (RMWST) is designed to meet peak demands from the RCS in conjunction with the design makeup requirements for the fuel storage pool and the refueling pool. The peak demand from the RCS is experienced when the plant is going to cold shutdown at approximately 80-percent core life, with 200 ppm boron in the reactor coolant system, with no control rods, and with equilibrium xenon, followed by a startup. The design makeup requirement for the fuel storage pool and the refueling pool is based on a pool temperature of 125°F.

POWER GENERATION DESIGN BASIS TWO - The reactor makeup water transfer pumps are designed to deliver 120 gpm to the boric acid blending tee, which is equivalent to the maximum letdown flow from the reactor coolant system. These pumps are also designed to deliver 150 gpm, as an alternate source, for cooling the contents of the pressurizer relief tank from 200°F to 120°F in one hour following a pressurizer safety valve discharge.

POWER GENERATION DESIGN BASIS THREE - The RMWS is designed to supply high quality degasified water to minimize corrosion in the systems supplied and which is compatible with the RCS water chemistry.

9.2.7.2 System Description

9.2.7.2.1 General Description

The RMWS, shown in Figure 9.2-13, consists of one storage tank, two transfer pumps and a tank steam coil heater, and the associated piping, valves, and instrumentation.

The RMWST receives water from four sources:

a. The demineralized water system

b. The waste evaporator condensate tank

c. The liquid radwaste treatment system

d. The secondary liquid waste monitor tanks via the demineralized water degasifier

The RMWS tank is provided with a diaphragm which is continuously in contact with the tank water surface. This prevents absorption of gases which would lower the water quality below that necessary for use as reactor makeup water. The reactor makeup water chemistry specifications are given in Table 9.2-15.

Overpressure/overflow protection for the RMWST is provided by a loop seal which drains to the waste holdup tank in the liquid radwaste system. The RMWST level is maintained above a specified minimum by manual replenishment from one of the four specified sources. Of these sources, the demineralized water system should be used to minimize buildup of the primary side water inventory once the other sources are exhausted.

The water temperature in the tank is maintained above freezing by an automatically controlled heater system. The heater system consists of steam coils wrapped around the outside of the reactor makeup water storage tank. Steam to these coils is provided by the auxiliary steam system and is controlled automatically to maintain the tank contents above 50°F.

The reactor makeup water transfer pumps, taking suction from the RMWST, are employed for various makeup and flushing operations throughout the nuclear steam supply system auxiliaries, the radwaste systems, and the fuel pool cooling and cleanup system. Table 9.2-20 gives a summary of the reactor makeup water requirements.

A sample connection is provided to allow periodic analysis of the RMWST contents.

The reactor makeup water is expected to have extremely low radioactive concentrations since the processed radwaste stream is recycled after processing. The radioactivity levels are discussed in Section 11.2.

The pipe routing of the RMWS is physically separated from essential systems, to the maximum extent practicable.

9.2.7.2.2 Component Description

The containment penetration associated with the RMWS is designed and constructed to quality group B and seismic Category I requirements. The balance of the system is designed and constructed in accordance with quality group D specifications.

REACTOR MAKEUP WATER STORAGE TANK - The tank is covered, vented, and insulated and is constructed of stainless steel. The tank is located outdoors. The tank contains a diaphragm and loop seal to maintain airtight integrity. Freeze protection is

provided by external steam heating coils. The useable capacity of the tank is 126,000 gallons.

REACTOR MAKEUP WATER TRANSFER PUMPS - The pumps are 100-percent system capacity, inline centrifugal type and are driven by constant speed electric motors. All parts in contact with the pumped fluid are stainless steel. The two pumps are connected in parallel with common suction and discharge lines.

9.2.7.2.3 System Operation

Makeup water is intermittently supplied to the RMWST from the waste evaporator condensate tank, the recycle evaporator, and the secondary liquid waste monitor tanks (via the demineralized water degasifier). Prior to being transferred to the RMWS, a sample is taken to assure that the processed water meets the design specifications given in Table 9.2-15. If the RMWST is out of service, these makeup sources can be supplied directly to the suction of the reactor makeup water transfer pumps.

Since most waste streams are recycled within the plant, it is highly desirable not to add makeup water from the demineralized water system until sources from the boron recycle, liquid radwaste, and secondary waste systems are used first. This will minimize the probability of the primary side of the plant becoming water bound.

In order to maintain the RMWST at a specified minimum water level, water from the demineralized water system is manually supplied to the RMWST by opening the air-operated supply valve. If the RMWST is out of service, this demineralized water supply can be manually transferred to the suction of the reactor makeup water transfer pumps.

The RMWS is normally kept at pressure by operating one of the two pumps in the run mode. Thus, reactor makeup water is available upon demand. The second pump is kept in the auto mode and will start upon low pressure in the discharge header. Once automatically started, the additional pump is manually stopped when the surge demand has passed. The RMWS is used to maintain proper boron concentration in the reactor coolant system and the preset level in the volume control tank by supplying makeup water to the boric acid blending tee.

The reactor makeup water transfer pumps are also operated locally and from the main control room to supply, as required, makeup and flush water to the various systems given in Table 9.2-20. These operations require manual actuation of the valves normally isolating the various connections to the given systems.

A recirculation line from the reactor makeup water transfer pump discharge to the RMWST is provided to protect the pumps during periods of system operation when there is little or no demand from the systems normally being supplied. This maintains the system in a ready state for any of the automatic demands.

Grab samples may be taken from the RMWST for analysis to assure that the quality of this makeup meets the chemical specifications for service in the RCS, as given in Table 9.2-15. If the reactor makeup requires purification, it can be recirculated through the recycle evaporator condensate demineralizer until the water chemistry is within specifications. If further processing is necessary, water from the RMWST can be directed through the recycle evaporator condensate demineralizer and into the recycle holdup tank for reevaporation, as described in Section 9.3.6.

The level indication on the RMWST and an imbalance of water addition versus controlled water discharge will alert the operator of any abnormal leakage from the system. In addition, the floor drain system described in Section 9.3.3 provides additional detection capabilities.

In the event of a LOCA, the containment must be isolated as described in Section 6.2.4. The containment penetration associated with reactor makeup water has a check valve, inside the containment, and a power-operated valve which automatically closes on a CIS-A, outside the containment.

9.2.7.3 Safety Evaluation

Except for an associated containment penetration, the RMWS is not a safety-related system.

SAFETY EVALUATION ONE - Sections 6.2.4 and 6.2.6 provide the safety evaluation for the system containment isolation arrangement and testability.

9.2.7.4 Tests and Inspections

Preoperational testing is discussed in Chapter 14.0.

The operability, performance, and structural and leaktight integrity of all system components is demonstrated by continuous operation.

9.2.7.5 Instrumentation Applications

Instrumentation is provided to measure the water level in the reactor makeup water storage tank and to give the main control room indication and annunciation of high and low levels. Level-control instrumentation is provided to stop the pumps on tank low-low level.

Instrumentation is provided to measure the water temperature in the reactor makeup water storage tank and to give the main control room indication as well as annunciation of high and low temperatures. Temperature-control instrumentation is provided to initiate and terminate the auxiliary steam supply to the heater coil.

Local pressure indicators are provided for the suction and discharge of the reactor makeup water transfer pumps.

Instrumentation is provided to measure the pressure in the common discharge line of the reactor makeup water transfer pumps, to give the main control room indication and annunciation of low system pressure, and to start the backup pump to maintain system pressure.

9.2.8 CLOSED COOLING WATER SYSTEM

The closed cooling water system (ClCWS) receives heat from the turbine building miscellaneous plant equipment and rejects it to the service water system.

9.2.8.1 Design Bases

9.2.8.1.1 Safety Design Bases

The ClCWS serves no safety function and has no safety design basis.

9.2.8.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - The ClCWS provides corrosion-inhibited, demineralized cooling water to the equipment shown in Table 9.2-21.

POWER GENERATION DESIGN BASIS TWO - During power operation, the ClCWS operates to provide a continuous supply of cooling water, at a maximum temperature of 105°F, to turbine plant equipment, with a service water inlet temperature of 95°F.

POWER GENERATION DESIGN BASIS THREE - The system is designed to permit the maintenance of any single active component without interruption of the cooling function.

POWER GENERATION DESIGN BASIS FOUR - Makeup to the system can be provided at a rate of 5 percent of the closed cooling water flow.

POWER GENERATION DESIGN BASIS FIVE - The surge tank is sized to provide at least 30 seconds of active storage.

9.2.8.2 System Description

9.2.8.2.1 General Description

The ClCWS is shown on Figure 9.2-14. The system consists of one surge tank, one chemical addition tank, two pumps, two heat exchangers (connected in parallel), and associated piping, valves, controls, and instrumentation. Heat is removed from the ClCWS, via the closed cooling water heat exchanger, by the service water system, which is described in Section 9.2.1.1.

A sample is periodically taken for analysis to assure that the water quality meets the chemical specifications given in Table 9.2-11 for the services indicated in Table 9.2-21.

9.2.8.2.2 Component Description

The ClCWS is designed and constructed in accordance with quality group D specifications.

CLOSED COOLING WATER SURGE TANK - The closed cooling water surge tank is covered, vented, and constructed of carbon steel. The tank is located in the turbine building. Demineralized water make-up is provided by a mechanical level control valve. The capacity of the tank is 866 gallons.

CLOSED COOLING WATER CHEMICAL ADDITION TANK - The closed cooling water chemical addition tank is constructed of carbon steel. Provisions for make-up water and addition of the chemicals are included. The tank is located in the turbine building. The capacity of the tank is 75 gallons.

CLOSED COOLING WATER PUMPS - The pumps are constant speed, electric motor-driven, horizontal centrifugal pumps. The two pumps are connected in parallel with common suction and discharge lines. The pumps operate at approximately 930 gpm.

CLOSED COOLING WATER HEAT EXCHANGERS - The closed cooling water heat exchangers are of horizontal shell and straight tube design. The tube side is supplied with service water, and the shell side is supplied with closed cooling water. The surface area is based on normal heat load.

9.2.8.2.3 System Operation

During normal power operation, one of the two 100-percent-capacity closed cooling water pumps circulates demineralized water through the shell of one of the two 100-percent-capacity closed cooling water heat exchangers. In the closed cooling water heat exchanger, heat is rejected to the service water passing through the tubes.

Cooling water flow rate to the electrohydraulic control (EHC) coolers, steam generator feed pump turbine lube oil coolers and is regulated by automatic control valves. Control valves in the cooling water outlet from these units are throttled in response to temperature signals from the fluid being cooled.

The flow rate of cooling water to all of the other coolers is manually regulated, by individual throttling valves located on the cooling water outlet from each unit.

The closed cooling water surge tank is located at an elevation above the highest component in the system and is connected to the pumps' suction. The surge tank

provides a reservoir for small amounts of leakage from the system and for the expansion and contraction of the cooling fluid with changes in the system temperature.

Demineralized water makeup to the CICWS is controlled automatically by a level control valve which is actuated by sensing surge tank level. A corrosion inhibitor is manually added to the system.

9.2.8.3 Safety Evaluation

The CICWS does not serve a safety-related system.

9.2.8.4 Tests and Inspections

Preoperational testing is described in Chapter 14.0. The performance, structural, and leaktight integrity of all system components is demonstrated by continuous operation.

9.2.8.5 Instrument Applications

Local indication of closed cooling water surge tank level is provided. Surge tank low and high level alarms are provided in the control room via the plant computer. Each pump discharge contains a pressure gauge.

Pressure indicator connections are provided where required for testing and balancing the system. Flow indicator taps are provided at strategic points in the system for initial balancing of the flows and for verifying flows during plant operation.

TABLE 9.2-1 SERVICE WATER SYSTEM FLOW REQUIREMENTS NORMAL POWER GENERATION OPERATION

Component	Flow Each (gpm)	Total Flow (gpm)	Duty Each (x 10^6 Btu/hr)	Total Duty (x 10^6 Btu/hr)
a. Closed cooling water heat exchangers	1,500	1,500	3.54	3.54
b. Central chiller condensing units	1,500	1,500	8.9	8.9
c. Steam packing exhauster	1,728	1,728	12.5	12.5
d. Breathing Air Compressor Heat Exchanger (1)	76	152	.50	1.01
e. Generator hydrogen coolers	1,580	3,160	11.99	23.98
f. Generator stator liquid coolers	2,388	2,388	17.9	17.9
g. Turbine-generator lube oil coolers	1,930	1,930	10.8	10.8
h. CVCS chiller	418	418	2.3	2.3
i. Steam-generator blowdown non-regenerative heat exchanger (max.)	1,475	1,475	18.5	18.5
j. Condenser vacuum pump seal water coolers (3)	700	2,100	.87	1.74
k. Motor-driven steam generator feedwater pump and coolers (4)	24	24	.48	.48

(1) Breathing air compressor heat exchangers are normally isolated during normal power generation operation.

(2) Deleted

(3) Flow is continuous to all three coolers - total heat duty applies to two of three coolers during full power operation.

(4) Flow is continuous - duty applies during start-up only.

TABLE 9.2-2 ESSENTIAL SERVICE WATER SYSTEM FLOW REQUIREMENTS NORMAL POWER GENERATION OPERATION

Equipment Description	Section Number	Number/ In Use	'A' Train Flow (gpm)/Duty (x 10^6 Btu/hr)	'B' Train Flow (gpm)/Duty (x 10^6 Btu/hr)	Total Duty (x 10^6 Btu/hr)
Component cooling water heat exchanger	9.2.2	2/1	13,500/78.65	0/0	78.65
Containment air cooler	6.2.2	4/4	2,200/6.76	2,200/6.76	13.52
Diesel generator cooler	9.5.5	2/0	1,200/0	1,200/0	0.0
Component cooling water pump room cooler	9.4.3	2/1	128/0.32	128/0	0.32
ECCS centrifugal charging pump room cooler	9.4.3	2/1	128/0.32	128/0	0.32
Auxiliary feedwater pump room cooler	9.4.3	2/0	128/0	128/0	0.0
Safety injection pump room cooler	9.4.3	2/0	88/0	88/0	0.0
RHR pump room cooler	9.4.3	2/0	88/0	88/0	0.0
Containment spray pump room cooler	9.4.3	2/0	88/0	88/0	0.0
Penetration room cooler (electrical)	9.4.3	2/2	100/.1	100/.1	.2
Fuel pool cooling pump room cooler	9.4.2	2/1	29/0.072	29/0	0.072
Control room a/c unit condenser	9.4.1	2/2	140/0.663	140/0.663	1.326
Class 1E switchgear a/c condenser	9.4.1	2/2	66/0.485	66/0.485	0.97
Air compressor and after cooler (1)	9.3.1	2/2	61/0.763	61/0.763	1.526
Flow to auxiliary feedwater system	10.4.9	---	0/NA	0/NA	---
Makeup to spent fuel pool cooling & cleanup system	9.1.3	---	0/NA	0/NA	---
Makeup to component cooling water sytem	9.2.2	---	0/NA	0/NA	---

(1) Values may vary with plant conditions; both are assumed to be operating.

TABLE 9.2-3 ESSENTIAL SERVICE WATER SYSTEM FLOW REQUIREMENTS POST-LOCA OPERATION[8]

Equipment Description	Section Number	Number/ In Use	'A' Train Flow (gpm)/ Duty ($x 10^6$ Btu/hr)[3]	'B' Train Flow (gpm)/ Duty ($x 10^6$ Btu/hr)[3]	Total Duty ($x 10^6$ Btu/hr)[2]
Component cooling water heat exchanger [1]	9.2.2	2/2	7,350/180 [9]	7,350/180 [9]	390
Containment air cooler	6.2.2	4/4	4,000/204.65 (2,000/100)	4,000/204.65 (2,000/100)	409.3 (200)
Diesel generator cooler	9.5.5	2/2	1,200/14.2	1,200/14.2	28.4
Component cooling water pump room cooler	9.4.3	2/2	128/0.16	128/0.16	0.32
ECCS centrifugal charging pump room cooler	9.4.3	2/2	128/0.16	128/0.16	0.32
Auxiliary feedwater pump room cooler [7]	9.4.3	2/2	128/0.32	128/0.32	0.64
Safety injection pump room cooler	9.4.3	2/2	88/0.135	88/0.135	0.27
RHR pump room cooler	9.4.3	2/2	88/0.16	88/0.16	0.32
Containment spray pump room cooler	9.4.3	2/2	88/0.13	88/0.13	0.26
Penetration room cooler (electrical)	9.4.3	2/2	100/0.16	100/0.16	0.32
Fuel pool cooling pump room cooler	9.4.2	2/2	29/0.072	29/0.072	0.144
Control room a/c unit condenser	9.4.1	2/2	140/0.663	140/0.663	1.326

TABLE 9.2-3 (Sheet 2)

Equipment Description	Section Number	Number/ In Use	'A' Train Flow (gpm)/ Duty (x 10^6 Btu/hr)(3)	'B' Train Flow (gpm)/ Duty (x 10^6 Btu/hr)(3)	Total Duty (x 10^6 Btu/hr)(2)
Class 1E switchgear a/c condenser	9.4.1	2/2	66/0.485	66/0.485	0.970
Air compressor and after cooler (4)	9.3.1	2/2	61/0.763	61/0.763	1.526
Maximum flow to auxiliary feedwater system (5&6)	10.4.9	-	1,120/NA	1,120/NA	-
Makeup to spent fuel pool cooling & cleanup systems (6)	9.1.3	-	25/NA	25/NA	-
Maximum makeup to component cooling water system (6)	9.2.2	-	100/NA	100/NA	-

NOTE: (1) Load does not occur until post-LOCA recirculation mode is initiated. This load is a conservative bound determined in the plant uprating report. For the purposes of determining system response to post LOCA heat loads, minor CCW heat loads such as the Safety injection and ECCS Centrifugal Charging Pump Oil coolers, and the Residual Heat Removal Pump Seal Cooler are considered to be encompassed by this bounding value.

(2) If single failure occurs in either train, the load shown in the opposite train will be the total.

(3) Peak duty is shown for each component. Actual duty is less and will reduce long term, as described in Section 9.2.5.

(4) Values may vary with plant conditions.

(5) Auxiliary feedwater system may be used to maintain steam generator water level post-LOCA.

(6) Flow shown would be maximum intermittent value expected.

(7) Heat load shown would be maximum intermittent value expected.

TABLE 9.2-3 (Sheet 3)

(8) The values specified in this table are nominal values based upon a UHS/ESW temperature of 95°F (see discussion in Section 9.2.1.2.3, Safety Evaluation Eight). The minimum required ESW flow rates are dependent on a number of factors including the number of tubes plugged on a heat exchanger, the fouling of the heat exchanger, heat loads of the components or room, process fluid flow rates, maximum calculated ESW temperature, and ESW flow rate through its associated cooling tower. The minimum acceptable ESW flow rates to these plant components are controlled by plant procedures.

(9) The required duty for the CCW heat exchanger is time dependent for post-LOCA conditions, particularly for the initial transient, as shown in Figure 9.2-15. Thus, the specified duty value is nominal only, as explained by Note (8). With regard to the safety function of the CCW heat exchanger(s), a sufficient amount of heat transfer is required in order to maintain the maximum CCW supply temperature to no more than 131°F.

TABLE 9.2-4 ESSENTIAL SERVICE WATER SYSTEM FLOW REQUIREMENTS NORMAL SHUTDOWN OPERATION[(4)]

Equipment Description	Section Number	Number/ In Use	'A' Train Flow (gpm)/ Duty (x 10^6 Btu/hr)	'B' Train Flow (gpm)/ Duty (x 10^6 Btu/hr)	Total Duty[(2)] (x 10^6 Btu/hr)
Component cooling water heat exchanger [(1)]	9.2.2	2/2	13,500/140.35	13,500/118.11	258.46
Containment air cooler	6.2.2	4/4	2,200/4.62	2,200/4.62	9.25
Diesel generator cooler	9.5.5	2/0	1,200/0	1,200/0	0.0
Component cooling water pump room cooler	9.4.3	2/2	128/0.32	128/0.32	0.64
ECCS centrifugal charging pump room cooler	9.4.3	2/0	128/0	128/0	0
Auxiliary feedwater pump room cooler	9.4.3	2/0	128/0	128/0	0
Safety injection pump room cooler	9.4.3	2/0	88/0	88/0	0.0
RHR pump room cooler	9.4.3	2/2	88/0.22	88/0.22	0.44
Containment spray pump room cooler	9.4.3	2/0	88/0	88/0	0.0
Penetration room cooler	9.4.3	2/2	100/0.10	100/0.10	0.20
Fuel pool cooling pump room cooler	9.4.2	2/2	29/.072	29/.072	0.144
Control room a/c unit condenser	9.4.1	2/2	140/0.663	140/0.663	1.326

TABLE 9.2-4 (Sheet 2)

Equipment Description	Section Number	Number/ In Use	'A' Train Flow (gpm)/ Duty (x 10^6 Btu/hr)	'B' Train Flow (gpm)/ Duty (x 10^6 Btu/hr)	Total Duty(2) (x 10^6 Btu/hr)
Class 1E switchgear a/c condenser	9.4.1	2/2	66/0.485	66/0.485	0.97
Air compressor and after cooler (3)	9.3.1	2/2	61/0.763	61/0.763	0.526
Flow to auxiliary feedwater system	10.4.9	-	-	0	-
Makeup to spent fuel pool cooling and cleanup system	9.1.3	-	-	0	-
Makeup to component cooling water system	9.2.2	-	-	0	-

NOTE: (1) Maximum duty from CCW occurs 4 hours after initiation of shutdown when the RHR system is brought into service, as described in Section 9.2.2. Flowrate listed represents the nominal flow with the CCW heat exchanger outlet flow control valves fully open. Actual flows will be less.

(2) Peak duty is shown for each component. Total duty to UHS is actually less and will reduce long term.

(3) Values may vary with plant conditions; both are assumed to be operating.

(4) The values specified in this table are nominal values based upon a UHS/ ESW temperature of 95°F (see discussion in Section 9.2.1.2.3, Safety Evaluation Nine). The minimum required ESW flow rates are dependent on a number of factors including the number of tubes plugged on a heat exchanger, the fouling of the heat exchanger, heat loads of the components or room, process fluid flow rates, maximum calculated ESW temperature, and ESW flow rate through its associated cooling tower. The minimum acceptable ESW flow rates to these plant components are controlled by plant procedures.

TABLE 9.2-5 ESSENTIAL SERVICE WATER SYSTEM AND UHS COOLING TOWER FAILURE MODES AND EFFECTS ANALYSIS

	Component	Failure	Comments
1.	ESW pump and associated supporting items	Fails to start on automatic signal.	Two pumps are provided. One is sufficient for post-LOCA heat removal.
2.	Supply isolation valve between SW and ESW system	Fails to close on automatic signal.	Second valve in series will provide isolation.
3.	Main outlet valve for containment air cooler	Fails to open on automatic signal.	Partial cooling still provided in addition to 100% cooling removal by redundant train.
4.	Supply valve to air compressor	Fails to close upon small break.	Continued use of the system will result in minimal loss of water. 100 percent of the heat load is removed by the redundant train.
5.	CCW heat exchanger inlet valve	Fails to open on automatic signal.	Two CCW heat exchangers and two paths are provided. One loop provides 100% cooling capacity.
6.	CCW heat exchanger main outlet valve	Fails to reposition on automatic signal.	Results in lower flows to other components (i.e. containment air cooler), hence reducing their efficiency. 100 percent of the heat load is removed by the redundant train.
7.	Return isolation valve between SW and ESW system	Fails to close on automatic signal.	Second valve in series will provide isolation.
8.	Return isolation valve to ultimate heat sink	Fails to open on automatic signal.	100 percent of the heat load is removed by the redundant train.

TABLE 9.2-5 (Sheet 2)

	Component	Failure	Comments
9.	UHS cooling tower bypass valve (EFHV0065, EFHV0066)	Fails to close on automatic signal	The cooling function of one safety train of essential service water is lost with the potential of overheating the UHS retention pond or not retaining sufficient 30-day inventory. Control room operators will be able to evaluate the situation and isolate the degraded train of essential service water within 70 minutes per plant procedures. Essential plant cooling requirements are met thereafter by the remaining operable essential service water and UHS safety train.

TABLE 9.2-5 (Sheet 3)

	Component	Failure	Comments
10.	Temperature control transfer handswitch (EFHS0067, EFHS0068)	Fails to transfer automatic control of UHS cooling tower bypass valves and cooling tower fans from ESW return (UHS inlet) temperature loops to ESW pump discharge (ESW supply) temperature loops (Item 11).	Given no other ESW/ UHS equipment failures, one ESW train must be secured within 7 days of the initiation of a large break LOCA initiation as discussed in Section 9.2.5.2.2.1. In order to mitigate a postulated failure of the temperature control handswitch, an emergency operating procedure step will continuously monitor the expected cooling tower fan performance and secure the failed ESW train if the control scheme is not performing as anticipated. Given the continuous monitoring required by the emergency operating procedure, this condition will be resolved within 24 hours of large break LOCA initiation.
11.	ESW supply temperature control loops (EFT-0061, EFT-0062)	Fails to properly control UHS cooling tower bypass valves and cooling tower fans.	The ESW supply (ESW pump discharge) temperature loops, up to the temperature control transfer handswitches (Item 10), are identical in function to the UHS cooling tower inlet temperature loops. Any failure in the ESW supply temperature loop circuitry would be bounded by the discussion under Item 10 above.

TABLE 9.2-5 (Sheet 4)

	Component	Failure	Comments
12.	UHS cooling tower discharge header (179-HBC-30” or 166-HBC-30”)	Passive failure of one discharge header within the UHS cooling tower.	The cooling function of two cooling tower cells which removes the heat from one essential service water train is lost. The essential plant cooling requirements are met by the remaining two cells which remove the heat from the other essential service water train.
13.	UHS cooling tower fan (CEF01A, B, C, or D)	Fails to start or run at correct speed on automatic signal.	The cooling function of one cooling tower cell is lost. The essential plant cooling requirements are met by two of the remaining cooling tower cells which remove the heat from the other essential service water train.
14.	Emergency DG (KKJ01A or B)	Fails to start or run and provide emergency power to the two train-related UHS cooling tower fans.	The cooling function of two cooling tower cells which remove the heat from one essential service water train is lost. The opposite train’s diesel power supply to the remaining two fans is available. Essential plant cooling requirements are met by the remaining two cells which remove the heat from the other essential service water trains.

TABLE 9.2-6 ESSENTIAL SERVICE WATER SYSTEM INDICATING AND ALARM DEVICES

Indication	Control Room	Local	Control Room Alarm[1]
ESW header flow rate	Yes	No	No
ESW supply temperature	Yes	No	No
ESW return temperature	No[2]	Yes	No
ESW flow to air compressors and aftercoolers	No[3]	Yes	Yes
Power-operated valve position (all valves)	Yes	Yes	No
ESW flow to containment coolers	No	Yes	Yes
ESW pump discharge pressure	Yes	Yes	Yes[4]
ESW flow to CCW heat exchangers	No	Yes	No
UHS cooling tower trouble	No	No	Yes[5]
UHS cooling tower fan speed	Yes	Yes	No
ESW pump intake water level	No[2]	Yes	Yes[6]
ESW pump discharge strainer high differential pressure	No[2]	Yes	Yes

(1) Control room annunciators also have indicating lights

(2) Main control room computer point only

(3) Instrumentation inputs to the Air Compressor Trouble alarm in the main control room

(4) Alarm on low discharge pressure

(5) Based on a combination of ESW pump run time, ESW return water temperature, UHS cooling tower fan operating (on/off) status, and UHS cooling tower bypass valve position

(6) Alarm on high and low water level

TABLE 9.2-7 COMPONENT COOLING WATER SYSTEM REQUIREMENTS NORMAL OPERATION(5)

Equipment Description	Section Number	Number/ In Use	A Train Flow (gpm) Duty (x 10^6 Btu/hr)	B Train Flow (gpm) Duty (x 10^6 Btu/hr)	Total Duty (x 10^6 Btu/hr)
Essential Components					
Residual heat removal heat exchangers	5.4.7 & 6.3	2/0	0/0	0/0	0.0
RHR pump seal coolers	5.4.7 & 6.3	2/1	6/0.03	0/0	0.03
ECCS centrifugal charging pump bearing oil coolers	9.3.4	2/1	45/0.08	0/0	0.08
Safety injection pump bearing oil coolers	6.3	2/1	25/0	0/0	0.0
Fuel pool cooling heat exchangers	9.1.3	2/1	3,000/5.28(4)	0/0	5.28(4)
Excess letdown heat exchanger	9.3.4	1/1	260/0	NA	0.0
Reactor coolant pumps Motor air coolers Upper bearing coolers Lower bearing coolers Thermal barrier cooling coils	5.0	4/4	2,064/9.28	NA	9.28
Nonessential Components (1)					
Reactor coolant drain Tank heat exchanger	11.2	1/1	225/2.24	NA	2.24
Letdown heat exchanger	9.3.4	1/1	700/10.4	NA	10.4
Seal water heat exchanger	9.3.4	1/1	375/2.40	NA	2.40
Recycle evaporator package	9.3.6	1/1	780/8.81(3)	NA	8.81(3)
Aux. steam radiation monitor RE-50		1/1	46/0.23	NA	0.23
Waste gas compressors (2)	11.3	2/1	100/0.25	NA	0.25
Catalytic hydrogen recombiners (2)	11.3	2/1	20/0.30	NA	0.30
Nuclear sample system sample cooler	9.3.2	1/1	84/0.59	NA	0.59
Waste evaporator package	11.2	1/1	780/0.0(3)	NA	0.0(3)
Secondary waste evaporator package	10.4.10	1/1	1,415/17.8	NA	17.8

(1) Nonessential components feed from either train.

(2) Each of the two components is supplied with cooling water at a rate of one-half of the flow rate shown; however, only one of the components is accepting a heat load.

TABLE 9.2-7 (Sheet 2)

(3) Both the Recycle Evaporator Package and the Waste Evaporator Package have calculated loads of 8.81 MBTU/HR. Only one of these loads is added in the Table due to the infrequent operation of the units.

(4) The value of 5.28 x 10E6 represents the heat load at the point in a fuel cycle where the largest magnitude of the combination of Reactor Core Decay Heat (RHR loads) and Spent Fuel Pool Loads will occur (400 days post refuel). This results in a conservative heat-loading situation when evaluating total system heat loads. For individual SPF heat exchanger loads, a partial reactor core offload will be bounded by 27.15 x 10E6 BTU/hr and a full core offload will be bounded by 63.41 x 10E6 BTU/hr (Ref. Table 9.1-4).

(5) The values specified in this table are nominal values. Minimum CCW flow rates are controlled by plant design documents and procedures.

TABLE 9.2-8 COMPONENT COOLING WATER SYSTEM REQUIREMENTS SHUTDOWN (@ 4 HOURS) OPERATIONS (7)

Equipment Description	Section Number	Number/ In Use	A Train Flow (gpm)/Duty (x 10^6 Btu/hr) (1)(2)	B Train Flow (gpm)/Duty (x 10^6 Btu/hr) (2)	Total Duty (x 10^6 Btu/hr)
Essential Components					
Residual heat removal heat exchangers	5.4.7 & 6.3	2/2	7,600/124.3	7,600/124.3	248.6
RHR pump seal coolers	5.4.7 & 6.3	2/2	6/0.03	6/0.03	0.06
ECCS centrifugal charging pump bearing oil coolers	9.3.4	2/2	45/0.08	45/0.08	0.16
Safety injection pump bearing oil coolers	6.3	2/2	25/0	25/0	0.0
Fuel pool cooling heat exchangers (3)	9.1.3	2/0	0/0	0/0	0.0
Excess letdown heat exchanger (4)	9.3.4	1/1	260/0.0	NA	0.0
Reactor coolant pumps Motor air coolers Upper bearing coolers Lower bearing coolers Thermal barrier cooling coils	5.0	4/1	2,064/2.32	NA	2.32
Nonessential Components					
Reactor coolant drain Tank heat exchanger	11.2	1/1	225/2.24	NA	2.24
Letdown heat exchanger	9.3.4	1/1	1,000/5.0	NA	5.0
Seal water heat exchanger (4)	9.3.4	1/1	375/2.40	NA	2.40
Recycle evaporator package	9.3.6	1/1	780/8.81(6)	NA	8.81(6)
Waste gas compressors (5)	11.3	2/1	100/0.25	NA	0.25
Aux. steam radiation monitor RE-50		1/1	46/0.23	NA	0.23
Catalytic hydrogen recombiners (5)	11.3	2/1	20/0.30	NA	0.30
Nuclear sample system sample cooler	9.3.2	1/1	84/0.59	NA	0.59
Waste evaporator package	11.2	1/1	780/0.0 (6)	NA	0.0 (6)
Secondary waste evaporator package	10.4.10	1/0	0/0	NA	0.0

TABLE 9.2-8 (Sheet 2)

NOTE:

(1) Two CCW pumps are operating in Train A, for cooling nonessential loads. Nonessential loads can be fed from either train.

(2) Peak duty is shown. Heat load is lower as shutdown progresses.

(3) Flow rate and heat load for the fuel pool cooling heat exchangers are not included in totals because, this load can be shed for up to 4 hours after initiation of RHR load. As the RHR heat load is reduced, or selected nonessential loads are dropped, the fuel pool cooling will be placed back into service.

(4) During emergency shutdowns, prior to placing the RHR system into service at 4 hours after shutdown, the seal water heat exchanger is required to cool a maximum of 120 gpm of water recirculated from the discharge of the ECCS charging pumps; and the excess letdown heat exchanger is required to cool a maximum of 60 gpm letdown flow to the PRT.

(5) Each of the two components is supplied with cooling water at a rate of one-half of the flow rate shown; however, only one of the components is accepting a heat load.

(6) Both the Recycle Evaporator Package and the Waste Evaporator Package have calculated loads of 8.81 MBTU/HR. Only one of these loads is added in the Table due to the infrequent operation of the units.

(7) The values specified in this table are nominal values. Minimum CCW flow rates are controlled by plant design documents and procedures.

TABLE 9.2-9 COMPONENT COOLING WATER SYSTEM REQUIREMENTS POST-LOCA (3)

Equipment Description	Section Number	Number/ In Use	A Train Flow (gpm)/Duty (x 10^6 Btu/hr) (1)	B Train Flow (gpm)/Duty (x 10^6 Btu/hr) (1)	Total Duty (x 10^6 Btu/hr)
Essential Components					
Residual heat removal heat exchangers	5.4.7 & 6.3	2/2	7,600/230 (4)	7,600/230 (4)	390
RHR pump seal coolers	5.4.7 & 6.3	2/2	6/0.03	6/0.03	0.06
ECCS centrifugal charging pump bearing oil coolers	9.3.4	2/2	45/0.08	45/0.08	0.16
Safety injection pump bearing oil coolers	6.3	2/2	25/0.03	25/0.03	0.06
Fuel pool cooling heat exchangers (2)	9.1.3	2/1	0/0	0/0	0.0
Excess letdown heat exchanger	9.3.4	1/0	0/0	NA	0.0
Reactor coolant pumps Motor air coolers Upper bearing coolers Lower bearing coolers Thermal barrier cooling coils	5.0	4/0	0/0	NA	0.0
Nonessential Components					
Reactor coolant drain Tank heat exchanger	11.2	1/0	0/0	NA	0.0
Letdown heat exchanger	9.3.4	1/0	0/0	NA	0.0
Seal water heat exchanger	9.3.4	1/0	0/0	NA	0.0
Recycle evaporator package	9.3.6	1/0	0/0	NA	0.0
Waste gas compressors	11.3	2/0	0/0	NA	0.0
Aux. steam radiation monitor RE-50		1/0	0/0	NA	0.0
Catalytic hydrogen recombiners	11.3	2/0	0/0	NA	0.0
Nuclear sample system sample cooler	9.3.2	1/0	0/0	NA	0.0
Waste evaporator package	11.2	1/0	0/0	NA	0.0
Secondary waste evaporator package	10.4.10	1/0	0/0	NA	0.0

TABLE 9.2-9 (Sheet 2)

NOTE:

(1) Peak duty is shown representing start of recirculation mode. Total duty will be reduced long term.

(2) Flow rate and heat load for fuel pool cooling heat exchangers are not included in totals, since they are not added until 4 hours after start of the recirculation mode when heat from other sources has been significantly reduced.

(3) The values specified in this table are nominal values. Minimum CCW flow rates are controlled by plant design documents and procedures.

(4) The required duty for the RHR heat exchanger is time dependent for post-LOCA conditions, particularly for the initial transient, as shown in Figure 9.2-16. Thus, the specified duty value is nominal only, as explained by Note (3). As the RHR heat exchanger is the largest single load for the CCW heat exchanger, the RHR heat exchanger performance is closely tied to CCW heat exchanger performance. For the latter, a sufficient amount of heat transfer is required in order to maintain the maximum CCW supply temperature to no more than 131ºF.

TABLE 9.2-10 COMPONENT COOLING WATER SYSTEM COMPONENT DATA (1)

Component Cooling Water Pump (all data is per pump)	
Quantity	4 (100% each)
Type	Horizontal centrifugal, splitcase dual volute with mechanical seals
Capacity, gpm (each)	11,025
TDH, ft	195
Material	
Case	Carbon steel
Impeller	Bronze
Shaft	Alloy steel
Design codes	ASME Section III, Class 3
Driver	
Type	Electric motor
Horsepower, hp	700 with a 1.0 service factor
RPM	1,180
Power supply	4,160 V, 60 Hz, 3-phase, Class 1E
Design code	NEMA
Seismic design	Category I
Component Cooling Water Heat Exchangers (all data is per exchanger)	
Quantity	2 (100% each)
Type	Horizontal shell and straight tube
Design duty normal operation (each), Btu/hr	77.18×10^6
U-Factor, Btu/hr-ft^2, F	
Clean	580
Dirty	221
Area, ft^2	31,917
Tube Side:	
Fluid	Service water/essential, service water
Number of passes	2
Temperature, in/out F (2)	95/106.4
Flow rate, gpm	13,500
Design pressure, psig	200
Design temperature, F	200
Material	
Tubes	Copper-nickel
Tube sheet	Carbon steel
Codes and standards	ASME Section III, Class 3,TEMA R
Seismic design	Category I

TABLE 9.2-10 (Sheet 2)

Shell Side:	
Fluid	CCW
Number of passes	2
Temperature, in/out F	119.7/105
Flow rate, gpm	10,501
Design pressure, psig	150
Design temperature, F	200
Material	Carbon steel
Codes and standards	ASME Section III, Class 3, TEMA R
Seismic design	Category I
Component Cooling Water Surge Tank	
Quantity	2
Type	Vertical
Capacity (each), gallon	5,000
Operating pressure/ temperature, psig/F	Atm/120
Design pressure/temperature, psig/F	150/200
Material	Carbon steel
Code	ASME Section III, Class 3
Seismic design	Category I
Component Cooling Water Chemical Addition Tank	
Quantity	1
Type	Vertical
Capacity, gallons	500
Operating pressure/ temperature, psig/F	90/ambient
Design pressure/temperature, psig/F	150/200
Material	Carbon steel
Code	ASME Section VIII
Piping, Fitting, and Valves	
Design pressure, psig	150
Design temperature	200
Material	Carbon steel
Design code	
Containment penetrations	ASME Section III, Class 2
Safety-related portion	ASME Section III, Class 3
Nonsafety-related portion	ANSI B31.1

NOTE: (1) The information in this table reflect nominal design specifications. Refer to plant design documents for specific component data.

(2) CCW heat exchanger temperature in/out are the normal expected operation values

TABLE 9.2-11 WATER CHEMISTRY SPECIFICATIONS FOR COMPONENT COOLING WATER SYSTEM AND CLOSED COOLING WATER SYSTEM

“Actual plant water chemistry parameters are controlled under the Chemistry Program and specified within applicable Chemistry Department Procedures.”

TABLE 9.2-12 COMPONENT COOLING WATER SYSTEM SINGLE ACTIVE FAILURE ANALYSIS

Component	Failure	Comments
1. CCW pump	Fails to start on automatic signal.	Four pumps are provided. One pump is sufficient for post-LOCA heat removal.
2. CCW heat exchanger bypass valve	Control loop drives valve full open.	Two separated cooling loops are provided. One loop provides 100% cooling capacity.
3. Motor-operated isolation valve on residual heat exchanger inlet	Fails to open on remote manual signal from main control room post LOCA.	Two residual heat exchangers and two flow paths are provided. Flow is required to one post LOCA.
4. CCW flow path, including heat exchanger shell	Failure of pressure boundary resulting in abnormal leakage and loss of system fluid.	Two separate cooling loops are provided. One loop provides 100% cooling capacity.
5. Power supply	Failure of both normal and preferred power supplies.	All Class 1E components automatically switch to operation from power supplied from emergency diesel generators.
6. Power supply	Failure of power supply bus to one train.	The other train is supplied from an independent and physically separated bus. Each train provides 100% cooling capacity.
7. Essential service makeup water supply valves	Failure to open valve if makeup is required.	Two separate cooling loops are provided. Makeup to either loop is sufficient.
8. Motor-operated isolation valves for supply to non-essential components	One valve fails to close on SIS or low surge tank level.	Two valves are provided in series. One valve closing provides isolation.
9. Motor-operated isolation valves for return from non-essential components	One valve fails to close on SIS or low surge tank level.	Two valves are provided in series. One valve closing provides isolation.
10. Motor-operated isolation valves for supply to essential components inside containment	One valve fails to close on CIS-B. Either valve closes upon receipt of spurious signal.	Two valves are provided in series. One valve closing provides isolation. Valves are provided in parallel. Opening valve within 10 minutes is sufficient for RCP motor bearing heat removal. CVCS seal injection provides diverse cooling for RCP seals.
11. Containment isolation valves for supply to essential components inside containment	One valve fails to close.	Two valves (one check and one motor operated closed by CIS-B) are provided in series. One valve closing provides isolation.

TABLE 9.2-12 (Sheet 2)

Component	Failure	Comments
12. Containment isolation valves for return line for reactor coolant pump thermal barrier	One valve fails to close on CIS-B. Either valve closes upon receipt of spurious signal.	Two valves are provided in series. One valve closing provides isolation. CVCS seal injection provides diverse cooling for RCP seals. Long-term requirements are met by opening parallel valves.
13. Containment isolation valves for return line for other essential components inside containment	One valve fails to close on CIS-B. Either valve closes upon receipt of spurious signal.	Two valves are provided in series. One valve closing provides isolation. Valves are provided in parallel. Opening valve within 10 minutes sufficient for RCP motor bearing heat removal.

TABLE 9.2-13 COMPONENT COOLING WATER SYSTEM, INDICATING AND ALARM DEVICES

Indication	Control Room	Local	Control Room Alarm
CCW heat exchanger flow	Yes	Yes	No
CCW heat exchanger inlet temperature	Yes	Yes	No
CCW heat exchanger outlet temperature	Yes	Yes	Yes
CCW pump suction pressure	No	Yes	No
CCW pump discharge pressure	Yes	Yes	Yes
CCW motor running lights	Yes	No	No
CCW heat exchanger inlet pressure	No	Yes	No
CCW heat exchanger outlet pressure	No	Yes	No
CCW flow to redundant safety-related equipment trains	Yes	Yes	Yes (1)
CCW flow to incontainment service	Yes	Yes	Yes (1)
CCW temperature out of safety-related equipment	No	Yes	No
CCW surge tank level	Yes	Yes	Yes
Radiation level of fluid	Yes	No	Yes
CCW flow from RCPs	No	Yes	Yes

NOTE: (1) Computer points alarm through Control Room monitor. RHR heat exchangers have MCB alarms.

TABLE 9.2-14 MAJOR COMPONENTS SUPPLIED WITH WATER FROM DEMINERALIZED WATER STORAGE AND TRANSFER SYSTEM

A. Condensate storage tank

B. Reactor makeup water storage tank

C. Component cooling water system

D. Closed cooling water system

E. Auxiliary steam system

F. DG cooling water expansion tank

G. Chilled water system

H. Hot water system

I. Miscellaneous laboratory and sampling requirements

J. Miscellaneous flushing requirements

K. Miscellaneous makeup requirements

L. Condensate pump seals

M. Condensate and chemical addition

N. Condensate demineralizer

O. Hardened condensate storage tank

TABLE 9.2-15 PLANT WATER CHEMISTRY SPECIFICATIONS

"Actual plant water chemistry parameters are controlled under the Chemistry Program and specified within applicable Chemistry Department Procedures."

TABLE 9.2-16

"Actual UHS chemistry parameters are controlled under the Chemistry Program and specified within applicable Chemistry Department Procedures."

TABLE 9.2-17 HEAT LOADS FROM STATION AUXILIARIES POST LOCA

Component	Section Number	Duty (Per Operating Train) (x 10^6 Btu/hr
RHR pump seal cooler	5.4.7 & 6.3	0.03
ECCS centrifugal charging pump bearing oil cooler	9.3.4	0.08
Safety injection pump bearing oil cooler	6.3	0.03
Diesel generator cooler	9.5.5	14.2
Component cooling water pump room cooler	9.4.3	0.16
ECCS centrifugal charging pump room cooler	9.4.3	0.16
Auxiliary feedwater pump room cooler	9.4.3	0.32
Safety injection pump room cooler	9.4.3	0.14
RHR pump room cooler	9.4.3	0.16
Containment spray pump room cooler	9.4.3	0.13
Penetration room cooler (Electrical)	9.4.3	0.16
Fuel pool cooling pump room cooler	9.4.2	0.07
Control room ac unit condenser	9.4.1	0.66
Class 1E switchgear ac condenser	9.4.1	0.49
Air compressor and after cooler	9.3.1	0.76

TABLE 9.2-18 HEAT LOADS FROM STATION AUXILIARIES NORMAL SHUTDOWN USING UHS COOLDOWN TO COLD SHUTDOWN

Component	Section Number	Total Duty (x 10^6 Btu/hr)
Reactor coolant pumps (4) Motor air coolers Upper bearing coolers Lower bearing coolers Thermal barrier cooling coils	5.0	2.32
RHR pump seal cooler	5.4.7, 6.3	0.06
Letdown heat exchanger	9.3.4	5.00
Seal water heat exchanger	9.3.4	2.40
Nuclear sample system sample cooler	9.3.2	0.59
Component cooling water pump room cooler (2)	9.4.3	0.64
RHR pump room cooler (2)	9.4.3	0.64
Penetration room coolers (2)	9.4.3	0.20
Fuel pool cooling pump room cooler	9.4.2	0.072
Control room ac unit condenser	9.4.1	0.663
Class 1E switchgear ac condenser (2)	9.4.1	0.98
Air compressor and after-cooler (2)	9.3.1	1.526
Total		15.09

TABLE 9.2-19 COMPONENTS AND SYSTEMS SERVED BY CONDENSATE STORAGE AND TRANSFER SYSTEM

COMPONENT/SYSTEM	FSAR SECTION
Condenser air removal system	10.4.2
Condenser hotwells	10.4.1
Condensate demineralizer	10.4.6
Auxiliary steam condensate recovery and storage tank	9.5.9
Auxiliary feedwater pumps	10.4.9

TABLE 9.2-20 SUMMARY OF REACTOR MAKEUP WATER REQUIREMENTS

Connection to System	Minimum [(1)] Required Flow (gpm)	Purposes
Boric acid blending tee[(2)]	120	To dilute the concentrated boric acid as required.
Boric acid blending tee	120	To supply makeup water to the refueling water storage tank (RWST).
Chemical mixing tank	1	For chemical addition.
Boric acid batch tank	80	Used in the production of the boric acid solution.
Boron thermal regeneration demineralizers	60	Alternate bed regeneration.
Emergency boration fill line	5	To flush the line.
Recycle evaporator condensate demineralizer	55	Water cleanup of RMWST.
Pressurizer relief tank	150 @ 90 psig	For alternate cooling.
Reactor coolant pump standpipes	10	Provide periodic degassed purge water to the RCP #3 seal on demand.
Chemical drain tank	5	To flush waste from drumming line back into tank.
Catalytic hydrogen recombiner	5	To force gases out of equipment prior to maintenance.
Liquid radwaste treatment system	10-30 @ 80 psig	To transfer resin and filter media.
Waste gas compressor	5	Compressor seal usage.
Gas decay tanks	30 @ 100 psig	Displace gas in decay tanks prior to maintenance.

TABLE 9.2-20 (Sheet 2)

Connection to System	Minimum [1] Required Flow (gpm)	Purposes
Spent resin storage tank (secondary)	20	To flush waste from drumming line back into tank and to provide demineralizer sluicing water to the tank.
Resin charging tanks (radwaste & CVCS)	20 each	To provide sluicing water.
Spent resin storage tank (primary)	20	To flush waste from drumming line back into tank and to provide demineralizer sluicing water to tank.
Sample sinks	5	General laboratory requirements.
Fuel storage pool	20	Fuel storage pool water makeup.
Spray booth	40	For preliminary decontamination prior to use in the chemical tanks.
Reactor vessel head storage area	40	Decontamination of the reactor vessel head.
Demineralized water degasifier	120	To remove dissolved oxygen in reactor makeup water.
Electrical control and hydraulic power unit	3	To provide makeup to ECH power unit reservoir.

TABLE 9.2-20 (Sheet 3)

Notes:

(1) Intermittent services. Atmospheric pressure at the connection unless otherwise specified.

(2) Maximum letdown rate.

TABLE 9.2-21 COMPONENTS COOLED BY THE CLOSED COOLING WATER SYSTEM

Equipment Description	Number/ in Use	Flow Each (gpm)	Total Flow (gpm)	Duty Each (Btu/hr)	Total Duty (Btu/hr)
Generator isophase bus duct coolers	2/1	149	149	1.5×10^6	1.5×10^6
Steam generator feed pump turbine lube oil coolers	4/2	240	480	6.0×10^5	1.2×10^6
EHC coolers	2/1	30	60	4.25×10^4	4.25×10^4 (1)
Condensate pump motor bearing oil coolers	3/3	8	24	1.53×10^4	4.59×10^4
Secondary system sample coolers	11/11	7	77	4,860	53,460
Heater drain pump					
motor bearing coolers	2/2	4	8	34,144	68,288
shaft seal coolers	2/2	15	30	50,000	100,000
Condensate demineralizer chiller unit	1/1	10	10	50,050	50,050
Auxiliary boiler and auxiliary steam Reboiler sample coolers	2/2	7	14	4,860	9,720
Steam generator wet layup recirculation sample coolers	4/4	7	28	4,860	19,440 (2)
Total			852		3,069,918

NOTES: (1) Flow is to two coolers but heat load is only from one cooler.

(2) Used only during plant shutdown, not included in total

TABLE 9.2-22 CONDENSATE STORAGE AND TRANSFER SYSTEM COMPONENT DATA

Non-Safety Auxiliary Feedwater Pump	
Quantity	1
Type	Horizontal centrifugal, multistage, split case
Nominal capacity, gpm	500
TDH, ft	3,460
NPSH required, ft	32
NPSH available, ft (nominal)	65
Material	
Case	Alloy steel
Impellers	Stainless Steel
Shaft	Stainless steel
Design code	Not applicable
Seismic design	Non seismic
Driver	
Type	Electric motor
Horsepower, hp	700
Rpm	3,580
Power supply	4,160 V, 60 Hz, 3-phase
Design code	NEMA
Seismic design	Non seismic

9.3 PROCESS AUXILIARIES

9.3.1 COMPRESSED AIR SYSTEM

The compressed air system (CAS) provides a reliable, continuous supply of filtered, dry, and oil-free air for instrument and control operations. The system also provides station air at service outlets throughout the plant for operation of pneumatic tools and other service requirements.

The CAS provides a reliable backup supply of compressed gas for the main feedwater control valves. The system also provides a safety-related backup compressed gas supply for the auxiliary feedwater control valves and the main steam atmospheric relief valves.

9.3.1.1 Design Bases

9.3.1.1.1 Safety Design Bases

The following safety design bases for the safety-related portions of the (CAS) are applicable to: the safety-related functions of containment isolation; the 8-hour (designed), 5-hour (required) backup air supply for the auxiliary feedwater control valves; the 8-hour (designed), 5-hour (required) backup air supply for the main steam atmospheric relief valves. The 5-hour supply required for the auxiliary feedwater control valves and the main steam atmospheric relief valves is minimum sufficient to mitigate the effects of a station blackout event or a steam generator tube rupture event. Operator action to refill the accumulators can extend the period in which these components can be used.

SAFETY DESIGN BASIS ONE - Portions of the CAS are protected from the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, and external missiles (GDC-2).

SAFETY DESIGN BASIS TWO - Portions of the CAS will remain functional after an SSE and will perform their intended function following postulated hazards of fire, internal missiles, or pipe break (GDC-3 and 4).

SAFETY DESIGN BASIS THREE - Component redundancy is provided so that safety functions can be performed, assuming a single active component failure coincident with the loss of offsite power (GDC-34).

SAFETY DESIGN BASIS FOUR - Active components of the CAS are capable of being tested during plant operation. Provisions are made to allow for inservice inspection of components at appropriate times specified in the ASME Boiler and Pressure Vessel Code, Section XI.

SAFETY DESIGN BASIS FIVE - The CAS is in accordance with the quality group classification assigned by Regulatory Guide 1.26 and the seismic category assigned by Regulatory Guide 1.29. The power supply and control functions are in accordance with Regulatory Guide 1.32.

SAFETY DESIGN BASIS SIX - The containment isolation valves in the system are selected, tested, and located in accordance with the requirements of 10 CFR 50, Appendix A, General Design Criteria 54 and 56, and 10 CFR 50, Appendix J Type C Testing.

9.3.1.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - The CAS provides compressed air for service outlets located throughout the plant and a continuous supply of filtered, dried, and essentially oil-free air for pneumatic instruments and valves.

POWER GENERATION DESIGN BASIS TWO - The combined air receiver storage capacity is adequate to supply instrument air requirements during the time required for the standby compressor to come up to pressure in the event of an operating compressor failure.

POWER GENERATION DESIGN BASIS THREE - The CAS has the capability of providing instrument air during loss of offsite power.

POWER GENERATION DESIGN BASIS FOUR - The CAS serving the main feedwater control valves provides a nonseismically qualified, nonsafety-related backup compressed gas system that is capable of simultaneously closing all four valves in the event of the loss of the normal air supply.

9.3.1.2 System Description

9.3.1.2.1 General Description

The CAS includes three identical skidmounted 60-percent-capacity air compressing trains, each consisting of an air inlet filter/silencer, a compressor unit, an aftercooler, an air receiver, and interconnecting piping and valving. The three air receivers are connected in parallel by a common header which branches into the instrument air and service air subsystems. Service air goes directly to distribution, while instrument air first passes through a drying/filtering train. All of the above components are located in the turbine building. Localized compressed gas cylinders and control valves are provided for the backup gas supply systems. Safety-related pneumatically operated valves are listed in Table 9.3-2. The CAS is shown in Figure 9.3-1.

9.3.1.2.2 Component Description

COMPRESSORS - The three air compressors are rotary screw, nonlubricated, water-cooled, two-stage, motor-driven units. Each of the compressors is rated to deliver 845 scfm at 128-psig discharge pressure. The compressors are sized so that each can supply an adequate supply of air for average instrument air requirements. The compressors are non-Class 1E devices two are powered from different Class 1E busses, and the third is powered from a non-Class 1E bus. The two compressors powered by the Class 1E busses are cooled by service water during normal plant operation and essential service water for all loss of offsite power conditions. Both compressors are shed from the Class 1E busses on a safety injection signal but may be realigned to the busses manually.

AFTERCOOLERS - Each of the three compressors is provided with an aftercooler to cool the flow of air from the associated air compressor to 110°F or lower. The aftercoolers are TEMA Class C air/ water heat exchangers cooled from the same water system as the air compressors.

AIR RECEIVERS - Compressed air from the outlet of each aftercooler flows through one of the three air receivers. The air receivers serve as a storage volume to supply a limited amount of compressed air following a compressor failure. The combined volume of the three air receivers provides greater than a 30-second supply of instrument air at rated flow while allowing air pressure to drop from 115 psig to no less than 80 psig. This allows time for the standby compressor to start and come up to pressure.

DRYER/FILTER TRAIN - The instrument air dryer/filter train consists of a series arrangement of two parallel prefilters, two parallel dual tower dryer units, and two parallel afterfilters. One or both parallel trains may be in use as required. Parallel filters allow cleaning or changing of filters during one-train system operation by diverting air flow through the parallel filter. Each air dryer section consists of an interconnected set of two desiccant chambers. Air flow is automatically alternated through each chamber to permit the simultaneous drying of air in one chamber and the drying of desiccant in the other chamber. Drying of the desiccant is accomplished by depressurizing the dessicant chamber and purging dry air through it.

ACCUMULATORS - The backup gas systems provided for the auxiliary feedwater control valves, main feed control valves, and main steam atmospheric relief valves as part of the compressed air system utilize carbon steel accumulators to store nitrogen for use in the event of loss of operation of the regular CAS. The supply of the nitrogen is from the service gas system (see Section 9.3.5). The main feedwater control valve accumulator and the auxiliary feedwater control valve/main steam atmospheric relief valves accumulators are designed to ASME Section III, Class 3. All accumulators have a minimum design pressure of 800 psig. The accumulator system is shown in Figure 9.3-1.

9.3.1.2.3 System Operation

The CAS provides a reliable, continuous supply of filtered, dry, and essentially oil-free instrument air for pneumatic instrument operation and the control of pneumatic valves. The CAS also supplies service air to service outlets throughout the plant for the operation of pneumatic tools and other service requirements.

Two of the three air compressors are normally available for service at all times, and the other compressor is on standby. In the event of loss of an operating compressor or heavy loads, the resulting low pressure will initiate an automatic start of the standby compressor. Automatic starts occur only on low pressure. The on-line compressors automatically load and unload in response to small system pressure variations to minimize the amount of compressor starts and stops required. The compressors automatically shut down after running unloaded for 20 minutes. The sequence of compressor starting can be varied to permit equal operating time for all three air compressors. System malfunctions and abnormal conditions are annunciated in the control room.

The discharge line from each air receiver is connected in parallel to a common header. The service air subsystem takes its supply from this common header to a separate service air header for direct distribution to the service air outlets located throughout the plant. The instrument air subsystem also takes its supply from this common header to the dryer/ filter train, where the air is processed to the required cleanliness and dew point. The train is sized to dry and filter at least 1000 scfm of instrument air flow to a dew point of (-)40°F or less at 128 psig.

The prefilters are designed to retain 99.8 percent of incident-entrained water and oil droplets 5.0 microns and larger, and the afterfilters are designed to retain particles 3.0 micron and larger.

The service air line is provided with an isolation valve that will automatically isolate the service air subsystem from the compressed air supply when the service air header pressure drops below 110 psig. This arrangement is provided to direct all of the compressed air to the instrument air subsystem to maintain instrument air pressure in the event of excessive demand.

The accumulator backup gas system is designed to supply compressed gas to designated valves in the event of the loss of the normal instrument air supply. A check valve in the nitrogen supply line feeding each accumulator and a check valve in the instrument air supply line feeding the valve actuators prevent stored N_2 from being vented from the accumulator during any means of loss of pressure in the nitrogen feed and/or normal instrument air supply line.

The pressure-reducing valve downstream of each accumulator is manually adjusted to supply accumulator air at a pressure 10 psig below the nominal instrument air line

pressure. A relief valve is provided for each accumulator and in the pipe downstream of each pressure-reducing valve.

9.3.1.3 Safety Evaluation

Safety evaluations are numbered to correspond to the safety design bases of Section 9.3.1.1.

SAFETY EVALUATION ONE - The safety-related portions of the CAS are located in the reactor and auxiliary buildings. These buildings are designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other appropriate natural phenomena. Sections 3.3, 3.4, 3.5, 3.7(B), and 3.8 provide the bases for the adequacy of the structural design of these buildings.

SAFETY EVALUATION TWO - The safety-related portions of the CAS are designed to remain functional after an SSE. Sections 3.7(B).2 and 3.9(B) provide the design loading conditions that were considered. Sections 3.5, 3.6, and 9.5.1 provide the hazards analyses to assure that a safe shutdown, as outlined in Section 7.4, can be achieved and maintained.

SAFETY EVALUATION THREE - The safety-related portions of the CAS are completely redundant. Therefore, no single failure will compromise the system's safety functions. All vital power can be supplied from either onsite or offsite power systems, as described in Chapter 8.0.

SAFETY EVALUATION FOUR - The CAS is initially tested with the program given in Chapter 14.0. Periodic inservice functional testing is done in accordance with Section 9.3.1.4. Section 6.6 provides the ASME Boiler and Pressure Vessel Code, Section XI requirements that are appropriate for the system.

SAFETY EVALUATION FIVE - Section 3.2 delineates the quality group classification and seismic category applicable to the safety-related portion of this system and supporting systems. Table 9.3-1 shows that the components meet the design and fabrication codes given in Section 3.2. All the power supplies and controls necessary for safety-related functions of the CAS are Class 1E, as described in Chapters 7.0 and 8.0.

SAFETY EVALUATION SIX - Sections 6.2.4 and 6.2.6 provide the safety evaluation for the system containment isolation arrangement and testability.

9.3.1.4 Tests and Inspections

Preoperational testing is described in Chapter 14.0.

Leaktight integrity of the CAS is demonstrated by a hydrostatic test performed per the requirements of applicable codes.

Air compressors and associated components on standby can be checked and operated periodically. Air filters are inspected for cleanliness, and the desiccant is changed when it no longer performs according to the manufacturer's specifications.

During the initial plant testing prior to reactor startup, all engineered safety features systems utilizing compressed air will be tested to ensure fail-safe operation upon loss of compressed air pressure.

The compressed gas accumulator systems can be isolated from the regular compressed air system and tested to ensure proper operation characteristics.

Inservice inspection will be performed for the safety-related portions of the system per the technical requirements of ASME Section XI, as described in Section 6.6.

9.3.1.5 Instrumentation Applications

The compressors and associated equipment are provided with local control panels. Air temperature and pressure are measured at multiple locations in the compression process for automatic protection of the compressors. Indicating lights are located in the control room to indicate equipment status. Control room indication and alarm are provided for air compressor header pressure. Service air/instrument air isolation valve status is also provided in the control room.

The instrument air dryer assembly consists of two dryer units in parallel. Each dryer is equipped with local pressure indicators. Local control panel and control room alarms are provided for high differential pressure across the dryer package, pre-filters, afterfilters, and high package discharge humidity and low package discharge pressure. Local hand switches are provided to permit the operators to open the standby dryer train isolation valves.

Continuous control room indication of the pressure of each safety-related accumulator is provided. Local pressure indicators are provided downstream of the accumulator pressure-reducing valves to permit local monitoring of the system pressure.

Local pressure indicators are provided for the air lines feeding the spent fuel pool transfer gate seals to permit local monitoring of the seal pressure.

9.3.2 PLANT SAMPLING SYSTEMS

The plant sampling systems consist of the following subsystems: 1) the nuclear sampling system, which is further divided into the primary sampling system (PrSS), and a radwaste sampling system (RWSS), 2) a process sampling system (PSS) for secondary side sampling, and 3) local grab sample provisions. These subsystems include equipment to collect representative samples of the various process fluids in a safe and convenient manner. The RWSS is located in the radwaste building, the PrSS in the auxiliary building sample room, and the PSS in the turbine building. These systems

include sample lines, valves, coolers, and automatic analysis equipment. A description of the equipment comprising these systems and their features relating to safety is presented in this section. Certain process sampling components are discussed in other sections. A safety-related containment hydrogen analyzer provided to monitor the containment atmosphere following a postulated LOCA is described in Section 6.2.5.5.4. A discussion of process radiation monitoring is provided in Section 11.5. A discussion of gas analysis associated with the gaseous radwaste hydrogen recombiner is provided in Section 11.3.

9.3.2.1 Design Bases

9.3.2.1.1 Safety Design Basis

The plant sampling system serves no safety function and has no other safety design basis, except for a containment isolation provision.

SAFETY DESIGN BASIS ONE - The containment isolation valves in the system are selected, tested, and located in accordance with 10 CFR 50, Appendix A, General Design Criteria 54, 55, and 56, and 10 CFR 50, Appendix J, Type C Testing.

9.3.2.1.2 Power Generation Design Basis

POWER GENERATION DESIGN BASIS ONE - The PrSS is designed to collect representative samples of fluids in the reactor coolant system and auxiliary system process streams, as listed in Table 9.3-3, for analysis by the plant operating staff (and because of these design features, the PrSS facilitates small chemical additions to the RCS on a continuous basis or by batch additions). Chemical and radiochemical analyses are performed on these samples to determine:

1. Boron concentration
2. Fission and corrosion product activity levels
3. Dissolved gas concentration
4. Halide concentration
5. pH and conductivity levels
6. Fission gas content
7. Gas compositions in various vessels

The results are used to:

1. Monitor core reactivity

2. Monitor fuel rod integrity

3. Evaluate ion exchanger and filter performance

4. Specify chemical additions to the various systems

5. Maintain acceptable hydrogen levels in the reactor coolant system.

6. Detect radioactive material leakage

POWER GENERATION DESIGN BASIS TWO - The RWSS is designed to collect samples of the fluids in the radwaste systems, as listed in Table 9.3-4, for analysis by the plant operating staff. Chemical and radiochemical analyses are performed on these samples to determine treatment or disposition of the collected batches.

POWER GENERATION DESIGN BASIS THREE - The PSS is designed to continuously monitor water samples from the turbine cycle and the circulating water system, as listed in Table 9.3-5. Water quality analyses are performed on these samples to determine:

1. pH and conductivity levels

2. Dissolved oxygen

3. Residual hydrazine

4. Sodium concentration

The above measurements are used to control water chemistry and to permit appropriate corrective action by the operating staff. In addition, grab sample capabilities are provided at each of these monitoring points to monitor other chemical species.

POWER GENERATION DESIGN BASIS FOUR - Local grab sampling stations, as listed in Table 9.3-6, are provided for process points which require heat tracing or sampling at a frequency of not more than once a week.

POWER GENERATION DESIGN BASIS FIVE - The PrSS, RWSS, PSS, and radwaste gas sampling system are designed and built to the codes listed in Table 3.2-1.

9.3.2.2 <u>System Description</u>

9.3.2.2.1 Primary Sampling System

The PrSS collects samples from the reactor coolant system and the auxiliary systems, as listed in Table 9.3-3, and brings them to a common location in a sample room in the auxiliary building. The PrSS consists of a primary sampling rack and a sampling panel. To minimize the source volume exposed at the primary sampling panel, the sampling

station components that retain potentially radioactive fluids, such as sample coolers, isolation valves, throttle valves, rod-in-tube flow control valves, and associated piping and tubing, are mounted on the primary sampling rack. The rack is located behind a 2-foot-thick concrete wall which provides radiation shielding. The primary sampling panel, located in front of the radiation shield wall, contains the grab sampling facilities. The PrSS is shown in Figure 9.3-2. The PrSS rack contains sample coolers which reduce the temperature of the samples to below 110°F (to permit the safe handling of samples). The sample cooler in the accumulator sample stream is not normally used. The PrSS sample coolers are cooled by the component cooling water system. Relief valves protect the system from overpressurization.

After temperature and pressure reduction, the PrSS samples are routed to a manual sample facility within an exhaust-ventilated, hooded enclosure to confine any leakage or spillage of radioactive fluids. Temperature and pressure indicators are provided to verify the sample conditions. Within the vented sampling hood are grab sample points for each stream and the sample pressure vessels. Any liquid leakage is collected in the sink and drained to the floor drain tank or the holdup tank for processing through the liquid radwaste system.

The PrSS is manually operated on an intermittent basis to provide samples for laboratory analysis, except that steam generator blowdown samples are continuously monitored for radioactivity by one process radiation monitor (described in Section 11.5) common to the four samples. Sample lines are purged before each sample is drawn to ensure that representative samples are obtained. Continuous monitoring of the water quality of the steam generator blowdown sample is provided on the PSS. The steam generator blowdown sample lines are provided with solenoid valves which are closed automatically if radioactivity approaching the limits discussed in Section 11.5 is detected in the steam generator sample, or if a containment isolation signal occurs. If the steam generator blowdown samples are needed after an automatic closure of the blowdown sample valves due to high radiation, the valves can be opened manually at the nuclear sampling panel. Continuous monitoring of the CVCS letdown line (failed fuel monitor) is discussed in Section 11.5.

The operating conditions of the PrSS are given in Table 9.3-3. The high-pressure reactor coolant system samples are collected at full process pressure and reduced temperature in sample pressure vessels. Samples can also be taken at reduced pressure through the rod-in-tube flow control valves. These vessels are designed for 3,000 psig at 600°F, and are equipped with quick-disconnect couplings to facilitate removal to the radiochemical laboratory for analysis. The RCS hot leg sample lines include a delay coil (sufficiently long tubing run) to permit the decay of N-16 before the sample leaves the containment. The reactor coolant system, chemical and volume control system, and accumulator samples require sufficient purge to ensure representative samples. System pressure provides the motive force for the purging flows. Purge time is determined for each sample by the flow rate and the individual sample line volume. Portions of the PrSS direct primary coolant purge flow to the volume control tank in the chemical and volume control system. Other purge flows are returned to the auxiliary building floor drain tank

and elsewhere, as shown in Figure 9.3-2. The sample sink drain, which may be contaminated with particulates or cleaning solutions, is also routed to the auxiliary building floor drain tank. Because portions of the PrSS returns primary coolant purge flow to the volume control tank, the PrSS can be used to add chemicals to the RCS on either a continuous basis or batch additions.

9.3.2.2.2 Radwaste Sampling System

The RWSS collects samples from the radwaste systems, as listed in Table 9.3-4, and brings them to the sample room in the radwaste building. The RWSS is manually operated on an intermittent basis to provide samples for laboratory analysis. The RWSS is shown in Figure 9.3-3. The RWSS samples are routed to a manual sample facility within an exhaust-ventilated, hooded enclosure. Within the vented sampling hood are grab sample points for each stream. Sample lines are purged before each sample is drawn to ensure that representative samples are obtained.

The design conditions of the RWSS are given in Table 9.3-4.

9.3.2.2.3 Process Sampling System

The purpose of the PSS is to provide the data necessary to implement procedures for controlling the water quality of the secondary plant systems listed in Table 9.3-5. The PSS, which is located in the turbine building, is shown in Figure 9.3-4.

The operating conditions of the PSS samples are given in Table 9.3-5. Roughing coolers are provided for the samples whose temperatures exceed 140°F. All samples are conditioned to 77 ± 1°F by a chilled water, constant-temperature bath.

Samples are analyzed, and the results are used for automatic or manual control of the process fluids. All analyzers are continuously monitoring representative samples. The sample line and sample sink drains in the PSS are collected in the secondary liquid waste system where they are processed for reuse.

9.3.2.2.4 Manual Grab Sample Stations

Manual grab sample stations are provided for the liquid and gaseous sample points which require sampling at a frequency of less than once a week or on a nonscheduled basis. All gas sampling stations are of the inline type which returns purge gases to the process lines. Quick-disconnect type couplings are used for sampling bottle connections to provide a convenient and expeditious way of sampling for the nuclear sampling system.

Grab sample points for primary and radwaste liquid and gases are identified in Table 9.3-6. No sample point is provided on the chemical mixing tank of the chemical and volume control system since chemical additives are preanalyzed before they are added to the mixing tank.

9.3.2.3 Safety Evaluation

Except for an associated containment penetration, the PSS is not a safety-related system.

SAFETY EVALUATION ONE - Sections 6.2.4 and 6.2.6 provide the safety evaluation for the system containment isolation arrangement and testability.

All PSS lines penetrating the containment can be isolated at the containment boundary by solenoid valves that close either upon receipt of a containment isolation signal or by manual actuation. (See Section 6.2.4 for a discussion of containment isolation.)

9.3.2.4 Tests and Inspections

Proper operation of the PrSS, RWSS, and PSS is initially demonstrated during preoperational testing.

The proper operation and availability of the PrSS and RWSS are proved in service by their use during normal plant operation. Samples from the PrSS and RWSS are drawn manually for laboratory analysis. The results of this analysis are checked by calibrating the laboratory instruments against known compositions or check sources.

The PSS draws continuous samples from the turbine cycle and the circulating water system for automatic or manual water quality analysis. The operation of the PSS is verified by observing that continuous sample flow is maintained through the analyzers. The calibration of the analyzers is checked periodically by comparing it with laboratory analysis of a grab sample from the same process. The output of the continuous analyzers is recorded, and abnormal values are alarmed.

9.3.2.5 Instrumentation Applications

The plant sampling systems use local pressure, temperature, and flow indicators to facilitate manual operation and to verify sample conditions before samples are drawn.

A radiation element continuously monitors the steam generator blowdown sample for primary-to-secondary tube leaks. In the event the steam generator blowdown samples exhibit high radioactivity, approaching the limits given in Section 11.5, the sample line isolation valves are automatically closed. Facilities for obtaining these samples are also provided at the nuclear sampling panel.

The PSS is equipped with continuous analyzers to monitor specific water quality conditions. Certain measurements, as indicated in Figure 9.3-4, are used to automatically control the chemical addition for pH and corrosion control. Indicators and manual controls are provided on the sampling panel to maintain the proper sample conditions of the water entering the analyzers. Grab sample points are also provided for

laboratory analysis verification of analyzer calibration. A chiller unit is provided to condition samples to the standard condition of 77 ± 1°F.

9.3.3 EQUIPMENT AND FLOOR DRAINAGE SYSTEM

The floor and equipment drainage system (FEDS) collects, monitors, and directs liquid waste generated within the plant to the proper area for processing or disposal.

9.3.3.1 Design Bases

9.3.3.1.1 Safety Design Bases

The following safety design bases are applicable to those portions of the FEDS which have safety-related functions of containment isolation, leak detection in safety-related pump rooms following a LOCA, isolation of auxiliary building drainage system discharge paths following a LOCA, leak detection in the diesel generator rooms, leak detection in the basement of the control building, and backflow prevention rooms housing redundant trains of safety-related equipment.

SAFETY DESIGN BASIS ONE - The FEDS is protected from the effects of all appropriate natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, and external missiles (GDC-2).

SAFETY DESIGN BASIS TWO - The FEDS is designed to remain functional after a SSE or to perform its intended function following postulated hazards of fire, internal missile, or pipe break (GDC-3 and 4).

SAFETY DESIGN BASIS THREE - Component redundancy is provided so that safety functions can be performed, assuming a single active component failure coincident with the loss of offsite power (GDC-34).

SAFETY DESIGN BASIS FOUR - The FEDS is designed so that the active components are capable of being tested during plant operation. Provisions are made to allow for inservice inspection of components at appropriate times specified in the ASME Boiler and Pressure Vessel Code, Section XI.

SAFETY DESIGN BASIS FIVE - The FEDS uses design and fabrication codes consistent with the quality group classification assigned by Regulatory Guide 1.26 and the seismic category assigned by Regulatory Guide 1.29. The power supply and control functions are in accordance with Regulatory Guide 1.32.

SAFETY DESIGN BASIS SIX - The capability to isolate components or piping is provided so that the FEDS' safety function will not be compromised. This includes isolation of components to deal with leakage or malfunctions. Drainage from safety-related equipment rooms is designed to prevent flooding via drainage piping backflow.

SAFETY DESIGN BASIS SEVEN - Instrumentation is provided which permits the detection of leakage from safety-related systems following a LOCA.

SAFETY DESIGN BASIS EIGHT - The containment isolation valves in the system are selected, tested, and located in accordance with the requirements of 10 CFR 50, Appendix A, General Design Criterion 56, and 10 CFR 50, Appendix J, Type C testing.

SAFETY DESIGN BASIS NINE - Instrumentation is provided which permits the detection of water accumulation that could affect the operation of safety-related equipment.

9.3.3.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - All FEDS subsystems are designed to prevent the uncontrolled discharge of radioactive effluent from the power block.

POWER GENERATION DESIGN BASIS TWO - All nonradioactive subsystems are designed to minimize the introduction of potentially radioactive contaminated materials.

POWER GENERATION DESIGN BASIS THREE - The design and arrangement of the sanitary drainage subsystem ensures that the introduction of potentially radioactive contaminated materials will not occur.

POWER GENERATION DESIGN BASIS FOUR - The FEDS is designed to adequately handle and process normal anticipated power block drainage without sump overflow. Radioactive and nonradioactive wastes are handled by separate subsystems.

POWER GENERATION DESIGN BASIS FIVE - The FEDS contains provisions for normal plant operation leakage detection.

The FEDS contains provisions for the detection of leakage from the reactor coolant system pressure boundary, containment cooler coil section, the spent fuel pool, transfer canal, cask loading pit, and refueling pool.

The FEDS serves to identify leakage that may occur in the event of a pipe rupture within the plant.

The collection piping within the FEDS is normally empty and is not a source of leakage. The discharge lines from the sump pump are normally full of water. Section 3.6 provides an evaluation which demonstrates that the pipe routing of the FEDS is physically separated from the essential systems to the maximum extent practical. Protection mechanisms, as required, are also discussed in Section 3.6.

9.3.3.2 System Description

9.3.3.2.1 General Description

The FEDS is shown in Figure 9.3-5. Major drainage areas are shown in Figure 9.3-6. The FEDS consists of several subsystems, as described below. Areas of the plant are served by the appropriate FEDS, based on the potential source of leakage into the subject area. This allows segregation of radioactive and nonradioactive sources. In addition, provisions are made in the appropriate subsystems for leak detection and isolation of portions of the subsystem to preclude degradation of safety-related functions.

9.3.3.2.1.1 Radioactive Drainage Areas

Radioactive FED subsystems include:

a. Potentially radioactive nontritiated waste (DRW)

b. Tritiated waste (CRW)

c. Chemical waste (ARW)

d. Detergent waste (SRW)

e. Potentially radioactive secondary liquid waste (LRW)

These subsystems are directed to and processed or disposed of by appropriate systems, as indicated in Figure 11.1A-1.

DRW SUBSYSTEM - The DRW subsystem consists of a network of floor and equipment drains arranged to collect potentially radioactive wastes with relatively low tritium levels from mechanical components, valve stem leakoffs, and maintenance drainage in the auxiliary, fuel, containment, radwaste, RAM Storage Building, and control buildings. Each building except RAM storage, is provided with a separate sump or group of sumps from which the collected waste is pumped to the floor drain tank for processing. The system also collects potentially radioactive tritiated waste from continuous equipment drains within the engineered safety features pump rooms and liquid collected by the leak detection subsubsystem of the DRW subsystem.

The leak detection subsubsystem consists of a network of leak chases, collection piping, and flow measuring standpipes for the refueling pool and fuel storage pool; standpipes for the containment coolers; level indicators for the containment normal sumps; RHR pump rooms sump; control building sumps, and the auxiliary building sump pit; and high level alarms for all sumps. The fuel storage pool standpipe measures combined leakage from the fuel storage pool, fuel transfer canal, and cask loading pool. In addition, all sump pump start and stop times are monitored and recorded by the plant computer.

The refueling pool and fuel storage pool leak detection systems utilize gravity flow leak collection chases positioned behind the liner plate welds. Vertical liner plate welds have structural steel channels seal welded behind the weld lines forming the collection chases. Horizontal liner plate welds have structural steel channels positioned under the weld lines. The leak chases are segregated into isolatable zones to facilitate leak location. Refer to Figure 9.3-7 for the leak chase zone and standpipe configuration. Each standpipe is capable of detecting a 1-gallon per minute leak within 60 minutes after leak initiation.

A condensate measuring standpipe is provided for each of the four containment coolers. The standpipes are similar in design to the pool standpipes, except that they measure containment cooler condensate in lieu of pool leakage. The standpipes are designed to preclude condensate backup into the containment coolers in the event of high condensate flow rates. The standpipes are capable of measuring a 1.0 gpm flow rate within 60 minutes after water vapor has reached the coolers and started to condense. The condensate flow rate during normal plant operation is used as the base rate when evaluating condensate flow rates to determine if abnormal flows are occurring. The containment cooler standpipes measure unidentifiable leakage rates, as defined in Section 5.2.5.

Sump level indicators in the containment, RHR pump rooms, auxiliary building, and instrument tunnel are used in conjunction with the plant computer to determine leak rates in the various buildings.

The safety-related level indication instrumentation in the sumps in the auxiliary building, RHR pump rooms, control building, and containment is located in a protected corner of the respective sump.

The RHR pump room instrumentation provides the earliest possible indication of a potential flooding condition in the safety-related pump rooms and, therefore, serves to protect the safety-related pumps. The auxiliary building sump instrumentation provides the earliest possible indication of a potential flooding condition in the auxiliary building at El. 1,974 corridors and areas open to the corridors and, therefore, serves to protect all equipment in the auxiliary building. The control building instrumentation provides early indication of a potential flood condition in the basement of the control building and, therefore, serves to protect the safety-related essential service water system components in that area. The containment instrumentation provides early indication of a potential flood condition in the containment and therefore serves to protect all safety-related equipment in the containment.

Each of the safety-related level indication units is designed to provide the control room with an analog indication of the water level within the instrument measurement range. No operator action is required for 30 minutes after initial indication. Refer to Appendix 3B for the design basis flood level.

The containment sumps and incore instrumentation sump indicators serve to measure unidentifiable leakage, as defined in Section 5.2.5.

In addition to providing the plant operators with a safety-related, Class 1E indication of water levels in the RHR pump room and the auxiliary building sump, the level indicators provide input to the plant computer.

High level alarms with control room annunciation are provided for all sumps. The alarm points are set above the highest normal sump pump actuation level. All sumps within the turbine building are provided with a common annunciator as are all the CRW and DRW sumps serving nonsafety-related systems. All other sumps are provided with unique and separate annunciators.

Safety-related components which are located in the lowest elevation of the auxiliary building are housed within watertight compartments. The drainage arrangement for that area is such that external drain or flood water is prevented from back flow into these areas, and flooding within rooms of one train of the safety-related components cannot communicate with the areas associated with the redundant train. Figure 9.3-6 shows the drainage arrangement associated with this area. Redundant check valves on the DRW subsystem discharge line from the control building are also provided to assure that there is no backflow.

The Boron Injection Tank (BIT) room differs from other compartments in the lowest level of the auxiliary building. The BIT room is not a watertight compartment because the drain for this room does not prevent backflow from a flood external to the compartment. Additionally, this compartment contains equipment for two redundant trains of safety-related equipment. The flood level in this room, from either internal or external sources, only affects a single train due to the differences in elevation of the vulnerable components between the two trains.

The DRW subsystem is designed with a segregated collection system for each of the safety-related pump trains so that crossflooding between trains will not occur. One sump for each safety-related train is provided and located in the RHR pump room. Sump pump discharge lines for these sumps are routed above the minimum watertight level and are provided with check valves internal and external to each room to preclude the sump pump discharge of one room from backflowing into the redundant room. The CRW subsystem equipment drains for the safety-related rooms are routed to a common sump external to the equipment rooms watertight boundary. The CRW equipment drains are capped during normal plant operation to prevent equipment room flooding from an external source. The CRW equipment drain caps may be removed during controlled maintenance operations to facilitate equipment drainage.

In the event of a LOCA, it is necessary to assure that any leakage from the ECCS be retained within the auxiliary building since airborne releases can be controlled and filtered, as discussed in Section 6.5. Redundant safety-related sump pump discharge isolation valves are provided which isolate on any SIS signal and prevent the discharge

of the auxiliary building and RHR pumproom DRW sump pumps from leaving the auxiliary building.

Seal failure and the resultant maximum seal leakage of 7.5 gpm from the ECCS and containment spray pumps is the only major credible source of leakage outside the containment following a LOCA. This leak rate is based on gross seal failure, as discussed in Section 6.3.

Containment isolation provisions on the DRW subsystem line which penetrates the containment include a normally open motor-operated valve inside and a normally closed air-operated valve outside. Both valves automatically close upon receipt of a CIS-A signal. An additional nonsafety-related solenoid is provided for the air-operated valve which, when energized, will open the valve. This occurs upon receipt of an indication of a running containment sump pump, except when a CIS-A signal is present. A high water level in a sump activates the associated pump.

Sumps collecting liquids for processing through oil/water separators all LRW subsystem sump pumps) are furnished with low shear double diaphragm pumps to preclude oil emulsification prior to oil/water separation.

CRW SUBSYSTEM - The CRW subsystem collects liquid waste which may contain relatively high tritium levels from equipment and valves within the auxiliary, radwaste, and fuel buildings. Separate sumps are provided in each building for effluent collection. Equipment drains only are provided for this system. The subsystem sump pumps discharge all collected effluent to the waste hold-up tank for processing and recycle.

ARW SUBSYSTEM - The ARW subsystem collects waste from selected laboratory sample sinks, and washdown wastes from the laundry decontamination facility, decontamination room decontamination tank. Waste collected by the hot laboratory sample sinks flows by gravity to a collection sump and is pumped to the chemical drain tank for processing and solidification. Waste from the reagent tanks, a radwaste building sample station, and the decontamination tank flow directly by gravity to the chemical drain tank.

SRW SUBSYSTEM - One subsystem collects waste from laboratory dishwashers (in the Communications Corridor), deep sinks, a washing machine and hot showers (in the Control Building). The collected waste flows by gravity to a stainless steel collection tank. Two pumps take suction from the tank and operate alternatively or in parallel to pump the effluent to the laundry and hot shower tank for processing. A basket strainer is provided in each pump suction line to filter out lint and debris.

A second subsystem collects waste from the Laundry Decontamination Facility, laundry washing machines and the laundry area. The collected waste flows by gravity to a sump in the laundry decontamination facility. Two pumps take suction from the sump and operate alternatively or in parallel to pump the effluent to the laundry and hot shower tank

for processing. A filter system is provided in the discharge line from the pumps to filter out lint and debris.

LRW SUBSYSTEM - The LRW subsystem collects normally nonradioactive but potentially radioactive turbine building drains and portions of the auxiliary building drains which do not normally house radioactive components. Two sumps are provided in the turbine building and one in the auxiliary building. The system discharges collected effluent to the secondary liquid waste processing system for recycle within the plant or discharge.

The system also includes a condensate collection tank and pump designed to hold and transfer recyclable condensate back to the condenser.

The Oil Waste (OW) and LRW subsystems both serve the turbine building. Six-inch curbs are provided between the subsystem drainage areas to assure that proper segregation of equipment leakages is maintained. The sump pump discharge lines for the two subsystems have independent discharge line isolation valves and a valved crossconnection. These pneumatically operated valves can be remotely operated so that the LRW subsystem can be aligned to discharge to the OW subsystem header or the OW subsystem aligned to discharge to the LRW subsystem header. A blind flange has been installed in the Turbine Building OW discharge line. Therefore, OW is processed through the LRW Subsystem.

Two 20-inch LRW drain lines are provided for the main steam/main feedwater isolation valve room in the auxiliary building to preclude flooding in the event of a postulated pipe break. The drain lines discharge into El. 2,000 of the turbine building.

9.3.3.2.1.2 Nonradioactive Drainage Areas

Nonradioactive FED subsystems include:

a. Sanitary waste (SAN)

b. Roof drains (RD)

c. Potentially oily waste (OW)

These subsystems are directed to and processed by or disposed of by an appropriate system, as indicated below.

SAN SUBSYSTEM - The SAN subsystem collects sanitary waste from service facilities, pantry facilities, electric water coolers, clean showers, plumbing fixtures, and toilet floor drains within the nonradioactive areas of the powerblock. The system is completely trapped and vented. The waste is collected in a gastight and vented concrete sump and pumped by a duplex arrangement of sump pumps to a sewage treatment plant for processing.

RD SUBSYSTEM - The roof drain subsystem collects water resulting from precipitation on all building roofs. The roof drain subsystem is sized at a design rainfall rate, as shown in Chapter 2.0. All the collected rainwater is conveyed by gravity to the site storm drainage system.

OW SUBSYSTEM - The OW subsystem collects nonradioactive liquid waste from the turbine building, diesel generator building, communciations corridor, control building, and selected areas of the auxiliary building. These nonradioactive wastes are collected in sumps and pumped to the LRW subsystem.

The diesel generator building sumps are provided with safety-related level indicators located in a protected corner of the respective sump. They provide the earliest possible indication of a potential flooding condition in the diesel rooms and therefore serve to protect the diesels and associated switchgear.

The OW drainage system serving the control room is provided with a loop seal to facilitate control room pressurization. Means for checking and maintaining the loop seal level are provided. Trapped and vented drains are provided for all powerblock battery rooms to assure that potentially noxious and corrosive vapors are retained within the battery rooms in the event of a gross battery failure. Acid neutralization tanks are also provided for the battery room drain headers to assure that the potentially corrosive effluents are neutralized with respect to pH prior to discharge from the powerblock.

9.3.3.2.2 Component Description

Codes and standards applicable to the FEDS are listed in Table 3.2-1. Except as discussed below, the design and construction of the FEDS is non-seismic Category I and quality group D. The containment penetration associated with the FEDS is designed and constructed to quality group B and seismic Category I requirements. Sump pump discharge isolation valves and level instrumentation for ECCS and containment spray pump areas which are required following a LOCA are designed and constructed to quality group C and seismic Category I.

COLLECTION PIPING - In areas of potential radioactivity, the collection piping is stainless steel except for portions of drain piping from the RAM Storage Building. The vertical portions of piping embedded in the concrete floor and extending from the RAM Storage Building floor drains into the Aux. Building Room 1401 are galvanized carbon steel piping. Stainless steel is also provided for nonradioactive battery room drains in the control building and drains in the turbine building for the collection of secondary side leakages and drainage. In nonradioactive areas where the collected effluent is discharged from the powerblock (OW, SAN, and RD subsystems), all embedded piping is cast iron. Suspended piping is galvanized steel or cast iron. The fabrication and installation of piping provides for a minimum uniform slope of 1/8 inch per foot to induce waste to flow in the piping. The piping is embedded where necessary for radiation shielding.

Equipment drainage piping is terminated not less than 3 inches above the finished floor.

EQUIPMENT DRAINS - Piped-up equipment drains are either routed directly to an embedded stub-up and seal welded in place or routed to an embedded stub-up and terminated in the open end. The connection to the stub-up varies as required for a particular application. In general, CRW subsystem drains carrying liquids with the potential for relatively high tritium levels are terminated with seal-welded connections while all others are terminated in the open end of drain hubs. Several equipment drains may terminate in one stub-up.

FLOOR DRAINS - All floor drains are installed with rims flush with the low point elevation of the finished floor. Floor drains in areas of potential radioactivity are welded directly to the collection piping and are provided with threaded plugs of the same material except for RAM Storage Building floor drains. A portion of the drain piping from the RAM Storage Buidling is installed with stainless steel Victaulic fittings. The plugs are used to seal the floor drains during hydrostatic testing of the drainage systems and during all required leak rate test procedures. They are also installed, as required, to preserve the integrity of the drainage systems. Floor drains in areas not restricted due to potential radioactivity are provided with caulked or threaded connections.

TRAPS - Inlets to the sanitary drainage system are provided with a water seal in the form of a vented P-trap to minimize entry of vermin and foul odors into the building. Air pressure vent lines to the outside atmosphere are provided downstream of the P-traps to prevent excessive backpressures which could cause blowout or siphonage of the water seal. A trapped header is provided to facilitate control room pressurization during control room isolation, as indicated in Section 6.4. Means for testing and filling the control room trap is provided. Trapped and vented drain lines are also provided for battery rooms in the control and turbine buildings.

Traps are not installed at inlets in oily, detergent, and chemical drainage subsystems or in areas of potential radioactivity to preclude the accumulation of radioactive liquids, oil, or detergents except for the RAM Storage Building floor drains. The RAM Storage Building floor drains each have a trap below them with a water seal to provide a pressure boundary with the Aux. Building.

CLEANOUTS - The DRW, OW, LRW, and SRW subsystems are provided with cleanouts when practical at the base of each vertical riser and at intervals of not more than 50 feet. Floor and equipment drains without traps are considered to be cleanouts for design purposes. The CRW, ARW subsystems, and leak detection subsystems are not provided with cleanouts because the effluents collected have a very low percentage of suspended solids. The sanitary drainage subsystem and roof drain are provided with cleanouts.

COLLECTION SUMPS - Sumps collecting potentially radioactive liquid (except the containment emergency recirculation sumps) are lined with stainless steel. The sumps are provided with a 1/2-inch-thick carbon steel cover used to support the sump controls

and sump pumps. The sumps (except LRW sumps) are vented to a filtered building exhaust system. The containment emergency recirculation sumps are lined with carbon steel. Radwaste building sumps and the ARW sumps are designed to accept a 12-inch-thick concrete cover in addition to the steel cover for additional shielding.

Sumps collecting nonradioactive liquid consist of concrete pits covered with 1/2-inch carbon steel cover plates. All sumps collecting nonradioactive fluids are locally vented, except for the sanitary drainage sump which is vented outside the powerblock through an independent vent.

All sump capacities are equal to or greater than the amount pumped from it in 5 minutes with one pump running.

All sumps have removable covers and/or inspection openings to facilitate sump cleaning and pump and controls inspection.

COLLECTION TANKS - Horizontal stainless steel tanks are used to collect SRW subsystem wastes and DRW reactor coolant pump lubricating oil leakage. The SRW subsystem tank is located in the control building and vented to a filtered exhaust system whereas the DRW subsystem tank is located in the containment and vented locally. A horizontal carbon steel tank in the LRW subsystem is used in the turbine building to collect main steam condensate. This tank is vented to a turbine building exhaust system. All tanks are provided with overflow connections.

ACID NEUTRALIZATION TANKS - Each battery room floor drain network is provided with an acid neutralization tank designed to neutralize the amount of acid contained within approximately 25 percent of the battery cells in the event of a break in the batteries. The tanks are stainless steel and filled with limestone as the neutralization agent. Liquid flows by gravity through the tanks and into the OW subsystem. The tanks are vented outside for removal of CO_2 generated during the neutralization process.

PUMPS - Vertical centrifugal sump pumps or double diaphragm sump pumps are provided for all sumps. Sumps lined with stainless steel have duplex stainless steel pumps while pumps in the concrete sumps are cast iron. Double diaphragm pumps are used to pump water which is to be processed through an oil-water separator and subsequently recycled. Duplex arrangements of sump pumps are provided in every case, except for pumps in the tendon access gallery, which are simplex. Submersible pumps are used in the incore instrumentation tunnel and the auxiliary building - radwaste building pipe tunnel. All sump pumps, except the sanitary lift station pumps, are provided with suction strainers designed to preclude the pumping of particles greater than 1/2-inch diameter. The sanitary lift station sump pumps are capable of pumping a spherical mass less than or equal to 2 1/2-inches in diameter.

Pump discharge rates are equal to or greater than the maximum anticipated drainage rates to the sumps during normal plant and/or maintenance operations.

9.3.3.2.3 System Operation

All of the FEDS subsystems utilize gravity drainage for the collection of the various effluents. All subsystems except the OW, roof drain, and leak detection subsystems utilize duplex arrangements of pumps at the collection point. The OW subsystem utilizes single pumps for the tendon access gallery and miscellaneous condensate drain tank and duplex pumps for all other applications. The roof drain and leak detection subsystems do not require pumps. The pumps (lead pump in a duplex configuration) are automatically activated when a predetermined high water level in the sump or tank is reached. Two pumps are actuated (duplex assemblies) when the water level rises to a predetermined high-high level. One pump will stop automatically when the liquid level falls below the high level set point. The lag pump will continue to operate until the water level is pumped down to a predetermined low level. The alternator automatically changes the actuation sequence for the lead and lag pump. High level alarms with computer annunciation are provided for all sumps and tanks.

The pneumatically operated containment isolation valve is normally closed and opens only in the event of a containment normal sump pump start in the absence of a containment isolation signal. The motor-operated containment isolation valve is normally open and closes in the event of a containment isolation signal.

The auxiliary building isolation valves are motor operated and normally open and close only in the event of a safety injection signal.

The leak detection system in the containment determines leak rates by calculating fill rates in sumps and standpipes. Standpipes utilize base-mounted pressure transmitters, to monitor standpipe water levels. The plant computer utilizes the pressure information and calculates incoming flow rates based on level changes resulting from the filling standpipes. The standpipes for the containment cooler, the refueling pool, and the spent fuel pool automatically drain following a standpipe high level and reset for continued operation. The level transmitters for the containment sumps provide an analog level signal to the plant computer. The plant computer is programmed to periodically calculate incoming flow rate and produce an alarm message if the flow rate increases by a predetermined amount.

9.3.3.3 Safety Evaluation

Safety evaluations are numbered to correspond to the safety design bases of Section 9.3.3.1.1.

SAFETY EVALUATION ONE - The safety-related portions of the FEDS are located in the reactor and auxiliary buildings. These buildings are designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other appropriate natural phenomena. Sections 3.3, 3.4, 3.5, 3.7(B), and 3.8 provide the bases for the adequacy of the structural design of these buildings.

SAFETY EVALUATION TWO - The safety-related portions of the FEDS are designed to remain functional after a safe shutdown earthquake. Sections 3.7(B).2 and 3.9(B) provide the design loading conditions that were considered. Sections 3.5, 3.6, and 9.5.1 provide the hazards analyses to assure that a safe shutdown, as outlined in Section 7.4, can be achieved and maintained.

SAFETY EVALUATION THREE - The safety-related portions of the FEDS are completely redundant and, as indicated by Table 9.3-7, no single failure will compromise the system's safety functions. All vital power can be supplied from either onsite or offsite power systems, as described in Chapter 8.0.

SAFETY EVALUATION FOUR - The safety-related portions of the FEDS are initially tested with the program given in Chapter 14.0. Periodic inservice functional testing is done in accordance with Section 9.3.3.4. Section 6.6 provides the ASME Boiler and Pressure Vessel Code, Section XI requirements that are appropriate.

SAFETY EVALUATION FIVE - Section 3.2 delineates the quality group classification and seismic category applicable to the safety-related portion of this system and supporting systems. Figure 9.3-5 shows that the components meet the design and fabrication codes given in Section 3.2. All the power supplies and controls necessary for safety-related functions of the FEDS are Class 1E, as described in Chapters 7.0 and 8.0.

SAFETY EVALUATION SIX - Section 9.3.3.2 describes the isolation provisions incorporated in the drainage system to ensure that any leakage that could occur following a LOCA is retained within an area which is served by a safety-related filtration exhaust system.

Section 9.3.3.2 also describes the segregated drainage system for each watertight safety-related component area and the barriers which prevent backflow.

SAFETY EVALUATION SEVEN - Safety-related level indicators are provided in each of the watertight areas which house the ECCS and containment spray pumps. Seal leakage from these pumps is the only major credible source of leakage following a LOCA. Redundant level indication is provided in the auxiliary building sump located in the sump pit of the basement of the auxiliary building to detect any long-term accumulation of fluid leaking from safety-related systems operating after a LOCA. Level instrumentation is discussed in Section 9.3.3.5. The drain configuration is indicated in Figure 9.3-6.

SAFETY EVALUATION EIGHT - Sections 6.2.4 and 6.2.6 provide the safety evaluation for the system containment isolation arrangement and testability.

SAFETY EVALUATION NINE - Safety-related level indicators are provided in the basement of the control building and in each diesel generator room to provide indication of a potential flooding condition in those areas. Refer to Section 9.5.1 for a description of flood damage protection during fire fighting operations.

9.3.3.4 Tests and Inspections

Preoperational testing is described in Chapter 14.0.

The performance and structural and leaktight integrity of system components is demonstrated by continuous operation.

The FEDS is testable through the full operational sequence that provides isolation following a LOCA, including operation of applicable portions of the protection system and transfer between normal and standby power.

The safety-related components are located to permit preservice and inservice inspections.

9.3.3.5 Instrumentation Application

The FEDS instrumentation is designed to facilitate automatic operation and remote control of the system and to provide continuous indication of system parameters.

Safety-related float-type level indicators are provided in the RHR pump room sumps, the auxiliary building sump, the control building sump, the diesel generators building sumps, and the containment normal sumps. In the event of a LOCA, these level devices monitor the performance of the safety-related systems by detecting leakage significant enough to result in detectable accumulation. The RHR pump room sump and auxiliary building sump level devices can detect the accumulated leakage resulting from a leak as small as 5 gpm within 30 minutes of the leak initiation. The level devices in the sumps will indicate the water level up to 5 feet 6 inches from the bottom of the sump for the control building sump (high level alarm at 4 feet 10 inches); up to 5 feet 6 inches above the top of the sump for the RHR pump rooms (high level alarm at 2 feet 2 inches from bottom of the sump); up to 5 feet 6 inches above the top of the sump for the auxiliary building (high level alarm at 2 feet 10 inches from the bottom of the sump); between 5 1/2 inches from the bottom of the sump to 2 feet 6 inches from the bottom of the diesel generator building sumps (high level alarm at 2 feet 2 inches); and up to 7 feet 6 inches from the bottom of the sump for the containment normal sumps (high level alarm at 3 feet 3 inches from the bottom of the sump).

Each FEDS normal sump operating level line which can discharge outside the standard power block is provided with a radiation monitor which will isolate the discharge path upon a high level indication. Section 11.5 discusses the process radiation monitors.

High level alarms with control room annunciation are provided for all sumps and tanks. All sumps within the turbine building are provided with a common annunciator as are all floor and equipment subsystem sumps serving nonsafety-related equipment. The sanitary drainage subsystem sump, chemical drain subsystem sump, detergent drain subsystem tank, sump serving the auxiliary feedwater pumps, sumps within the diesel generator building, pump serving the auxiliary boiler room, sumps within the

containment, and sumps inside of the safety features equipment rooms are provided with unique and separate annunciators. Each high level alarm is set to annunciate at a level above that required to actuate both pumps of a duplex sump pump arrangement or one pump of a simplex sump arrangement.

Hand switches with indicator lights are provided in the control room for sumps inside the containment and the sump pumps within the safety features pump rooms to permit remote sump pump actuation. All other pumps are provided with local hand switches.

Instrumentation is provided for the spent fuel pool and refueling pool to measure pool leak rates and each containment cooler to measure condensate flow rates. Standpipes with automatic drain controls are used and can detect a one gallon per minute leak within 60 minutes of leak initiation. A periodic update of the leak rate is provided by the plant computer. Also, instrumentation is provided for the instrument tunnel sump and the containment normal sumps, which provide data to the plant computer for leak rate calculations.

The detergent waste system basket strainers are provided with instrumentation to determine strainer pressure drop. A high pressure drop condition is alarmed in the control room.

Controls and instrumentation are provided for all pneumatic and motor-actuated valves to permit remote operation and provide indication of valve position. This includes containment isolation valves, spent fuel pool standpipe valves (leak detection subsystem), refueling pool standpipe valves (leak detection subsystem), oily waste discharge isolation valves, containment cooler standpipe valves (leak detection subsystem), auxiliary building sump discharge isolation valves, and the secondary liquid waste to oily waste system isolation valves.

9.3.4 CHEMICAL AND VOLUME CONTROL SYSTEM

The chemical and volume control system (CVCS) performs the following functions:

a. The CVCS maintains the required water inventory in the reactor coolant system (RCS) during normal operation, power changes, startup, and shutdown, including pressurizer auxiliary spray for depressurization. The CVCS also provides reactor grade water to the reactor coolant pump seals for cooling and sealing purposes and provides a means of pressure testing the RCS.

b. The CVCS varies the RCS soluble neutron absorber (boron) concentration to compensate for core burn-up. The CVCS provides sufficient boron, in the form of boric acid, to maintain the required shutdown margin during refueling.

c. The CVCS and boron thermal regeneration subsystem (BTRS) vary the RCS boron concentration to compensate for xenon transients and other reactivity changes which occur when the reactor power changes during load following, shutdowns, and startups.

d. The CVCS functions to maintain the desired RCS water chemistry conditions and reduce the radioactivity level.

e. Portions of the CVCS (i.e., ECCS charging pump subsystem) provide an injection flow to the RCS upon receiving a safety injection signal. The term “centrifugal charging pump” or “CCP” refers to the safety-related ECCS pumps only (PBG05A and PBG05B). The normal charging pump or NCP (PBG04) does not serve an ECCS function (the NCP is tripped by a safety injection signal).

f. The CVCS provides normal makeup to the RWST and spent fuel pool.

g. For safety grade cold shutdown, part of the CVCS functions in conjunction with other systems of the cold shutdown design.

The boron recycle system is discussed in Section 9.3.6.

9.3.4.1 Design Bases

9.3.4.1.1 Safety Design Basis

Portions of the CVCS associated with emergency boration (via BAT or RWST), charging for ECCS, reactor coolant pressure boundary isolation and containment isolation are safety related. These portions are required to function following a DBA and to achieve and maintain the plant in a safe shutdown condition.

SAFETY DESIGN BASIS ONE - The CVCS is protected from the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, and external missiles (GDC-2).

SAFETY DESIGN BASIS TWO - The pressure boundary of the CVCS is designed to remain intact after an SSE, some of the system components are designed to remain functional after an SSE, and the system is designed to perform its intended function following postulated hazards, internal missiles, or pipe breaks (GDC-3 and 4).

SAFETY DESIGN BASIS THREE - Safety functions can be performed, assuming a single active component failure coincident with the loss of offsite power (GDC-26 and 35).

SAFETY DESIGN BASIS FOUR - The active components are capable of being tested during plant operation. Provisions are made to allow for inservice inspection of

components at appropriate times specified in the ASME Boiler and Pressure Vessel Code, Section XI (GDC-32, 36, and 37).

SAFETY DESIGN BASIS FIVE - The CVCS is designed and fabricated to codes consistent with the quality group classification assigned by Regulatory Guide l.26 and the seismic category assigned by Regulatory Guide 1.29. The power supply and control functions are in accordance with Regulatory Guide 1.32.

SAFETY DESIGN BASIS SIX - The capability to isolate components or piping is provided so that the CVCS's safety function will not be compromised. This includes the isolation of components to deal with leakage or malfunctions and to isolate nonsafety-related portions of the system.

SAFETY DESIGN BASIS SEVEN - The containment isolation valves in the system are selected, tested, and located in accordance with the requirements of GDC-55 and 10 CFR 50, Appendix J, Type C Testing.

SAFETY DESIGN BASIS EIGHT - The CVCS provides diverse means of borating the RCS to a concentration that exceeds the requirement for a safe shutdown of the reactor from any operating condition, assuming that the control rod cluster with the highest reactivity worth is stuck in its fully withdrawn position and in the unlikely event that safe shutdown is initiated from peak xenon conditions. This amount of boric acid also exceeds the amount required to bring the reactor to a hot shutdown condition and to compensate for the subsequent reactivity transient resulting from xenon decay (GDC-27 and 29).

SAFETY DESIGN BASIS NINE - The CVCS has sufficient makeup capacity to maintain the required RCS water inventory in the event of a reactor coolant system leak resulting from an equivalent pipe break opening of 3/8-inch (liquid service) diameter or less (GDC-33).

SAFETY DESIGN BASIS TEN - The ECCS centrifugal charging pump subsystem of the CVCS in conjunction with other systems, provides a borated injection flow to the RCS upon receipt of a safety injection signal. The charging pump subsystem (PBG05A, PBG05B) of the CVCS is an integral part of the ECCS.

SAFETY DESIGN BASIS ELEVEN - Should only safety related equipment be available, the ECCS centrifugal charging pump subsystem of the CVCS functions in conjunction with other systems of the cold shutdown design to borate the RCS to a cold shutdown concentration.

9.3.4.1.2 Power Generation Design Basis

POWER GENERATION DESIGN BASIS ONE - The CVCS regulates the concentration of chemical neutron absorber (boron) in the reactor coolant to control reactivity changes resulting from the change in reactor coolant temperature between cold shutdown and hot

full-power operation, burnup of fuel and burnable poisons, buildup of fission products in the fuel, and xenon transients. The CVCS is capable of borating the RCS through either one of two flow paths and from either one of two boric acid sources.

POWER GENERATION DESIGN BASIS TWO - The CVCS is capable of controlling the changes in the reactor coolant boron concentration to compensate for the xenon transients during loadfollow operations, without adding makeup for either boration or dilution. This is accomplished by the boron thermal regeneration process, which is designed to allow load-follow operations as required by the design load cycle.

POWER GENERATION DESIGN BASIS THREE - The CVCS maintains the coolant inventory in the RCS within the allowable pressurizer level range for all normal modes of operation, including startup from cold shutdown, full power operation, and plant cooldown. This system also has sufficient makeup capacity to maintain the minimum required inventory in the event of minor RCS leaks.

POWER GENERATION DESIGN BASIS FOUR - The CVCS is capable of removing fission and activation products, in ionic form, gaseous form, or as particulates, from the reactor coolant in order to provide access to those process lines carrying reactor coolant during operation and to reduce activity releases due to leaks.

POWER GENERATION DESIGN BASIS FIVE - The CVCS provides a means for adding chemicals to the RCS to control the pH of the coolant during initial startup and subsequent operation, scavenge oxygen from the coolant during startup, and counteract the production of oxygen in the reactor coolant due to radiolysis of water in the core region. Oxygen control is also provided by maintaining dissolved hydrogen in the reactor coolant to scavenge oxygen.

The CVCS is capable of maintaining the oxygen content and pH of the reactor coolant within the limits specified in Table 5.2-5.

POWER GENERATION DESIGN BASIS SIX - The CVCS is able to continuously supply filtered water to each reactor coolant pump seal, as required by the reactor coolant pump design and as specified in Table 9.3-8.

POWER GENERATION DESIGN BASIS SEVEN - The CVCS is capable of supplying water at the required test pressure to verify the integrity of the RCS. The hydrostatic test is performed prior to initial operation and as part of the periodic RCS inspection program. The CVCS system may also be used for hydrostatic testing of the RCS following maintenance, where required.

With the removal of the Positive Displacement Pump (PDP), the CVCS requires the addition of a hydrostatic test pump in order to supply water at the required test pressure to verify the integrity of the RCS. The hydrostatic test performed prior to initial operation used the PDP. Periodic testing of the RCS integrity is conducted as delineated in Code Case N-498-1. This Code Case allows performing a system leakage test at or near the

end of each inspection interval, prior to reactor startup, as an alternative to the 10 year system hydrostatic test. The pressurizer heaters may be used to aid in achieving the desired test pressure. The hydrostatic test performed prior to initial operation used the Positive Displacement Pump. With the removal of the PDP, an additional hydrostatic test pump would be required to achieve the desired test pressure.

POWER GENERATION DESIGN BASIS EIGHT - The letdown and excess letdown lines between the points where they connect to the reactor coolant system and the points where they penetrate the secondary shield wall contain sufficient volume to delay the flow for 60 seconds during maximum letdown to allow the N-16 activity to decay.

POWER GENERATION DESIGN BASIS NINE - The purification and BTRS portions of the CVCS use design and fabrication codes consistent with quality group D (augmented), as assigned by Regulatory Guide 1.143 for radioactive waste management systems. The codes and standards to which individual components of the CVCS are designed are listed in Section 3.2.

9.3.4.2 System Description

9.3.4.2.1 General Description

The CVCS is shown in Figure 9.3-8, with system design parameters listed in Table 9.3-8. The CVCS consists of several subsystems: the charging, letdown, and seal water system; the reactor coolant purification and chemistry control system; the reactor makeup control system; and the boron thermal regeneration system. CVCS operation during accident mitigation is discussed in Section 6.3.

Section 3.6 provides an evaluation demonstrating that pipe routing of the CVCS is physically separated from essential systems to the maximum extent practicable. Protection mechanisms that are required are also discussed in Section 3.6.

9.3.4.2.1.1 Charging, Letdown, and Seal Water System

The charging and letdown functions of the CVCS are employed to maintain a programmed water level in the RCS pressurizer, thus maintaining a proper reactor coolant inventory during all phases of plant operation. This is achieved by means of a continuous feed-and-bleed process during which the feed rate is automatically controlled, based on the pressurizer water level. The bleed rate can be chosen to suit various plant operational requirements by selecting the proper combination of letdown throttle valves in the letdown flow path.

Reactor coolant is let down to the CVCS from a reactor coolant loop cross-over leg. It then flows through the shell side of the regenerative heat exchanger where its temperature is reduced by heat transfer to the charging flow passing through the tubes. The coolant then experiences a large pressure reduction as it passes through the letdown throttle valve(s) and flows through the tube side of the letdown heat exchanger

where its temperature is further reduced. Downstream of the letdown heat exchanger, a second pressure reduction occurs. This second pressure reduction is performed by the low pressure letdown valve, which maintains upstream pressure and thus prevents flashing downstream of the letdown throttle valves.

The coolant then flows through one of the mixed bed demineralizers. The flow may then pass through a cation bed demineralizer, which is used intermittently when additional purification of the reactor coolant is required.

From a point upstream of the BTRS or from a point upstream of the reactor coolant filters, a small sample flow may be diverted from the letdown stream to the boron concentration measurement system (see Section 7.7). The read-out on the boron concentration is given in the main control room.

During reactor coolant boration and dilution operations, especially during load follow, the letdown flow leaving the demineralizers may be directed to the BTRS. The coolant then flows through the reactor coolant filter and into the volume control tank (VCT) through a spray nozzle in the top of the tank. Hydrogen is supplied, when required, to the VCT where it mixes with fission gasses which are stripped from the reactor coolant into the tank gas space. The contaminated hydrogen is vented to the gaseous waste processing system. The partial pressure of the hydrogen gas mixture in the VCT determines the concentration of hydrogen dissolved in the reactor coolant for control of the oxygen produced by radiolysis of the water in the core.

Three charging pumps (the normal charging pump (NCP) and two ECCS centrifugal charging pumps) are provided to take suction from the volume control tank and return the purified reactor coolant to the RCS. Normal charging flow is handled by one of the three charging pumps. This charging flow splits into two paths. The bulk of the charging flow is pumped back to the RCS cold leg through the tube side of the regenerative heat exchanger. The letdown flow in the shell side of the regenerative heat exchanger raises the charging flow to a temperature approaching the reactor coolant temperature. Two charging paths are provided from a point downstream of the regenerative heat exchanger. A flow path is also provided from the regenerative heat exchanger outlet to the pressurizer spray line. An air-operated valve in the spray line is employed to provide auxiliary spray to the vapor space of the pressurizer during plant cooldown. This provides a means of cooling and mixing the pressurizer contents near the end of plant cooldown, when the reactor coolant pumps, which normally provide the driving head for the pressurizer spray, are not operating. Should only safety grade equipment be available, depressurization could be performed by the cold shutdown design, also described in Appendix 5.4A.

A portion of the charging flow is directed to the reactor coolant pumps (RCP) (nominally 8 gpm per pump) through a seal water injection filter. The flow is directed to a point above the pump shaft bearing. Here the flow splits, and a portion (nominally 5 gpm per pump) enters the RCS through the labyrinth seals and thermal barrier. The remainder of the flow is directed upward along the pump shaft to the number 1 seal leakoff. The

number 1 seal leakoff flow from the four RCPs discharges to a common manifold, exits from the containment, and then passes through the seal water return filter and the seal water heat exchanger to the suction side of the charging pumps, or by alternate path to the volume control tank. A very small portion of the seal flow leaks through to the number 2 seal. A stand-pipe provides a head for the number 3 seal which provides a final barrier to leakage of reactor coolant to the containment atmosphere. The number 2 seal leakoff flow is discharged to the reactor coolant drain tank in the liquid waste processing system. The number 3 seal overflow is discharged to the containment normal sump (this leakoff flow consists of a portion of the reactor makeup water which is supplied by the RCP seal standpipe). As discussed in Section 5.4.1.2.2, the RCP shaft seal system is designed for continued operation with either seal water injection or component cooling water to the RCP thermal barrier.

The excess letdown path is provided as an alternate letdown path from the RCS in the event that the normal letdown path is inoperable or provides insufficient capacity. Reactor coolant can be discharged from a crossover leg to flow through the tube side of the excess letdown heat exchanger where it is cooled by component cooling water. Under emergency shutdown conditions, the letdown flow can be diverted downstream of the excess letdown heat exchanger to the pressurizer relief tank. Under normal conditions, downstream of the heat exchanger, a remote-manual control valve is used to control the letdown flow. The flow normally joins the RCP number 1 seal discharge manifold and passes through the seal water return filter and heat exchanger to the suction side of the charging pumps. The excess letdown flow can also be directed to the VCT or the reactor coolant drain tank. When the normal letdown line is not available, the purification path is also not in operation. Therefore, this alternate condition would allow continued power operation for a limited period of time, dependent on RCS chemistry and activity. The excess letdown flow path is also used to provide additional letdown capability during the final stages of plant heatup. This path removes some of the excess reactor coolant due to coolant expansion as a result of the RCS temperature increase. Should RCS inventory letdown be required, a safety grade letdown path via the excess letdown heat exchanger to the pressurizer relief tank (PRT) is provided. This assures the capability to provide an RCS inventory letdown path should normal letdown paths become unavailable. This path may be used in conjunction with other features of the safety grade cold shutdown system which is discussed in Appendix 5.4A.

A cross tie line is provided connecting the charging line to the normal letdown line. This line provides a continuous flowpath from the charging to letdown lines in order to prevent void formation in the event of a letdown isolation.

Surges in the RCS inventory due to load changes are accommodated for the most part in the pressurizer. The volume control tank provides additional surge capacity for reactor coolant expansion not accommodated by the pressurizer. If the water level in the volume control tank exceeds the normal operating range, a proportional controller modulates a three-way valve downstream of the reactor coolant filter to divert a portion of the letdown to the boron recycle system. If the high level limit in the volume control tank is reached,

an alarm is actuated in the control room and the letdown flow is completely diverted to the boron recycle system, which is described in Section 9.3.6.

Low level in the volume control tank initiates makeup from the reactor makeup control system. If the reactor makeup control system does not supply sufficient makeup to keep the volume control tank level from falling to a lower level, a low alarm is actuated. Manual action may correct the situation or, if the level continues to decrease, a low-low level signal from either level channel causes the suction of the charging pumps to be transferred from the volume control tank to the refueling water storage tank and closes the volume control tank outlet isolation valve in the respective channel(s).

If required, a hydrostatic test pump can be connected to the CVCS in order to perform hydrostatic tests which verify the integrity and leaktightness of the RCS. The pump can pressurize the RCS to the maximum designated test pressure (see Table 9.3-8). The hydrostatic test is performed prior to initial operation, following maintenance where required, and is part of the periodic RCS inservice inspection program.

9.3.4.2.1.2 Reactor Coolant Purification and Chemistry Control System

Reactor coolant water chemistry specifications are given in Table 5.2-5.

pH CONTROL - The pH control chemical employed is lithium hydroxide. This chemical is compatible with the materials and water chemistry of borated water/stainless steel/ zirconium/ inconel systems. In addition, lithium-7 is produced in the core region due to the irradiation of the dissolved boron in the coolant.

The concentration of lithium-7 in the RCS is maintained in the range specified for pH control (see Table 5.2-5). If the concentration exceeds this range the cation bed demineralizer is employed in the letdown line in series operation with a mixed bed demineralizer. Since the amount of lithium to be removed is small and its buildup can be readily calculated, the flow through the cation bed demineralizer is not required to be full letdown flow. The cation demineralizer is in use approximately one percent of the time (or as necessary). If the concentration of lithium-7 is below the specified limits, lithium hydroxide can be introduced into the RCS via the charging flow, or via alternate suitable flowpaths. The solution is prepared in the laboratory and is added via various installed plant systems or components. Reactor makeup water, or other suitable liquid, may then be used to flush the solution into the RCS.

SHUTDOWN CHEMISTRY - In order to prevent formation of a flammable/explosive atmosphere within containment following venting of the RCS or removal of the reactor vessel head, and to promote removal of corrosion products from the reactor coolant system, reactor coolant chemistry is controlled in accordance with plant procedures to establish the following conditions during the specified phases of cooldown.

1. Acid reducing conditions are established in MODE 3 by borating the RCS and maintaining dissolved hydrogen within limits.

2. In MODE 5, RCS dissolved hydrogen is decreased by mechanical and/or chemical degassing (refer to Section 11.3.2.3).

3. Acid oxidizing conditions are established in MODE 5 following or in conjunction with mechanical and/or chemical degassing by performing RCS forced oxidation (refer to Section 9.1.4.2.3.1).

During the chemical and/or mechanical degasification and forced oxidation phases of cooldown, both hydrogen and oxygen may be present in the VCT vapor space. To mitigate the potential for formation of an explosive atmosphere, procedural controls on VCT level are established, and the VCT vapor space is monitored at procedurally specified intervals and purged to the gaseous radwaste system.

In preparation for and during plant shutdown conditions, a mixed bed demineralizer loaded with the necessary quantity of lithiated or non-lithiated resin may be placed in service to extend the service life of the cation and remaining mixed bed demineralizer used during the cycle. Non-lithiated resin is also compatible with the materials of construction and water chemistry of the borated water/stainless steel/zirconium/inconel systems.

OXYGEN CONTROL - During reactor startup from the cold condition, and at other times as necessary, hydrazine is employed as an oxygen scavenging agent. The hydrazine solution may be introduced into the RCS in the same manner as described above for the pH control agent.

Dissolved hydrogen is employed to control and scavenge oxygen produced due to radiolysis of water in the core region. A sufficient partial pressure of hydrogen is maintained in the VCT so that the specified concentration of hydrogen is maintained in the reactor coolant. A pressure control valve maintains a minimum pressure in the vapor space of the volume control tank. This valve can be adjusted to provide the correct equilibrium hydrogen concentration (25 to 50 cc hydrogen at STP per kilogram of water). Hydrogen is supplied from the hydrogen manifold in the service gas system.

Mixed bed demineralizers are provided in the letdown line to provide cleanup for the letdown flow. The demineralizers remove ionic corrosion products, certain fission products and zinc acetate during periods of zinc injection. One demineralizer is normally in continuous service and can be supplemented intermittently by the cation bed demineralizer, if necessary, for additional purification. The cation resin removes principally cesium and lithium isotopes from the purification flow. The second mixed bed demineralizer serves as a standby unit for use if the operating demineralizer becomes exhausted during operation or for RCS purification purposes in support of plant shutdown conditions.

A further cleanup feature is available for use during cold shutdown and operation of the residual heat removal system (RHRS). A remote-operated valve admits a bypass flow from the RHRS into the letdown line upstream of the letdown heat exchanger. The flow

passes through the heat exchanger, a mixed bed demineralizer, and the reactor coolant filter to the VCT. The fluid is then returned to the RCS via the normal charging route.

Filters are provided at various locations to ensure filtration of particulate and resin fines and to protect the seals on the reactor coolant pumps.

Fission gases are removed from the reactor coolant by purging of the VCT to the gaseous waste processing system.

ZINC ADDITION - A soluble zinc compound may be added to the reactor coolant as a means to reduce radiation fields within the primary system. The zinc used may be either natural zinc or zinc depleted of ^{64}Zn. When used, the target system zinc concentration is normally maintained to a concentration no greater than 40 ppb.

9.3.4.2.1.3 Reactor Makeup Control System

The soluble neutron absorber (boric acid) concentration is controlled by the BTRS and by the reactor makeup control system which controls the makeup water concentration at a pre-set value between 0 and 7700 ppm boric acid solution. The reactor makeup control system is also used to maintain proper reactor coolant inventory. In addition, for emergency boration and makeup, the redundant capability exists to supply borated water, at a minimum 2350 ppm boric acid concentration, directly from the refueling water storage tank to the suction of the charging pumps. When this source is used for boration, letdown from the RCS is required. Emergency boration utilizing only safety grade equipment is discussed in Appendix 5.4A.

The reactor makeup control system provides a manually preselected makeup concentration of boric acid to the charging pump suction header or to the volume control tank. The makeup control functions are those of maintaining desired operating level in the VCT and adjusting reactor coolant boron concentration for reactivity control. Reactor makeup water and boric acid solution (7000-7700 ppm) are blended together to achieve the desired boron concentration for use as makeup to maintain volume control tank level or to change the reactor coolant boron concentration.

A boron concentration measurement system (see Section 7.7) is provided to monitor the boron content of the reactor coolant in the letdown line. The boron concentration is indicated in the main control room.

Boric acid solution, at 7000 to 7700 ppm boron, is stored in two boric acid tanks. Two boric acid transfer pumps are provided which are capable of supplying the boric acid solution directly to the charging pumps' suction header upon remote manual demand from the main control room. The boric acid transfer pumps are normally aligned to recirculate the boric acid tank contents via the minimum flow lines and will supply boric acid to the boric acid blending tee upon demand of the reactor makeup control system. This boric acid is blended with reactor makeup water and delivered to the VCT inlet or outlet for injection into the reactor coolant system. The boric acid transfer pumps are

Class 1E devices which are normally supplied by the Class 1E power source, but have non-Class 1E controls and are shed from the busses upon a safety injection signal. They can be manually loaded on the standby diesel generator as needed, if offsite power is lost.

All portions of the CVCS which normally contain concentrated boric acid solution (7000 to 7700 ppm boron) are located within a heated area in order to maintain the solution temperature at ≥ 65°F, as discussed in Section 9.4.

The reactor makeup water pumps, taking suction from the reactor makeup water storage tank, are employed for various makeup and flushing operations throughout the systems. One of these pumps is normally running and provides flow to the boric acid blending tee or chemical mixing tank. The standby pump will auto-start on low pressure in the discharge header.

During reactor operation, changes are made in the reactor coolant boron concentration for the following conditions:

a. Reactor startup - Boron concentration must be decreased from shutdown concentration to achieve criticality.

b. Load follow - Boron concentration must be either increased or decreased to compensate for the xenon transient following a change in load.

c. Fuel burnup - Boron concentration must be decreased to compensate for fuel burnup and the buildup of fission products in the fuel.

d. Cold shutdown - Boron concentration must be increased to the cold shutdown concentrations.

The BTRS is normally used to control boron concentration to compensate for xenon transients during load follow operations. Boron thermal regeneration can also be used in conjunction with dilution operations of the reactor makeup control system to reduce the amount of effluent to be processed by the boron recycle system.

The reactor makeup control system (RMCS) can be set up for the following modes of operation:

a. Automatic Makeup

The "automatic makeup" mode of operation of the reactor makeup control system provides blended boric acid solution, preset to match the boron concentration in the RCS. Automatic makeup compensates for minor leakage of reactor coolant without causing significant changes in the reactor coolant boron concentration.

Under normal plant operating conditions, the mode selector switch is set in the "automatic makeup" position. This switch position establishes a preset control signal to the total makeup flow controller and establishes positions for the makeup stop valves for automatic makeup. The boric acid flow controller is set to blend to approximately the same concentration of borated water contained in the RCS. A preset low level signal from the VCT level controller causes the automatic makeup control action to start a boric acid transfer pump, open the makeup stop valve to the charging pump suction, and position the boric acid flow control valve and the reactor makeup water flow control valve. The flow controllers then blend the makeup stream according to the preset concentration. Makeup addition to the charging pump suction header causes the water level in the VCT to rise. At a preset high level point, the makeup is stopped. This operation may be terminated manually at any time.

If the automatic makeup fails or is not aligned for operation and the VCT level continues to decrease, a low level alarm is actuated. Manual action may correct the situation or, if the level continues to decrease, redundant low-low level signals open redundant isolation valves in the refueling water supply line to the charging pumps and closes the redundant isolation valves in the VCT outlet line.

b. Dilution

The "dilute" mode of operation permits the addition of a preselected quantity of reactor makeup water at a preselected flow rate to the RCS. The operator sets the mode selector switch to "dilute," the total makeup flow controller setpoint to the desired flow rate, and the total makeup batch integrator to the desired quantity and initiates system start. This opens the reactor makeup water flow control valve and opens the makeup isolation valve to the VCT inlet. Excessive rise of the VCT water level is prevented by automatic actuation (by the tank level controller) of a three-way diversion valve which routes the reactor coolant letdown flow to the boron recycle system. When the preset quantity of water has been added, the batch integrator causes the makeup to stop. Also, the operation may be terminated manually at any time.

Dilution can also be accomplished by operating the BTRS in the boron storage mode, as described in Section 9.3.4.2.1.4.

c. Alternate Dilution

The "alternate dilute" mode of operation is similar to the dilute mode, except that a portion of the dilution water flows directly to the charging pump suction and a portion flows into the VCT via the spray nozzle and

then flows to the charging pump suction. This decreases the delay in diluting the RCS caused by directing dilution water to the VCT inlet.

d. Boration

The "borate" mode of operation permits the addition of a preselected quantity of concentrated boric acid solution at a preselected flow rate to the RCS. The operator sets the mode selection switch to "borate," the concentrated boric acid flow controller setpoint to the desired flow rate, and the concentrated boric acid batch integrator to the desired quantity and initiates system start. This opens the makeup isolation valve to the charging pumps suction, positions the boric acid flow control valve, and starts the selected boric acid transfer pump, which delivers a 7000 to 7700 ppm boric acid solution to the charging pumps suction header. The total quantity added in most cases is so small that it has only a minor effect on the VCT level. When the preset quantity of concentrated boric acid solution is added, the batch integrator causes the makeup to stop. Also, the operation may be terminated manually at any time.

Boration can also be accomplished by operating the BTRS in the boron release mode, as described in Section 9.3.4.2.1.4.

e. Manual

The "manual" mode of operation permits the addition of a preselected quantity and blend of the boric acid solution to the refueling water storage tank, to the recycle holdup tanks in the boron recycle system, and to the spent fuel pool, or to some other location via a temporary connection. While in the manual mode of operation, automatic makeup to the RCS is precluded. The discharge flow path must be prepared by opening the manual valves in the desired path.

The operator sets the mode selector switch to "manual," the boric acid and total makeup flow controllers to the desired flow rates, and the boric acid and total makeup batch integrators to the desired quantities and actuates the makeup start switch.

The start switch actuates the boric acid flow control valve and the reactor makeup water flow control valve and starts the boric acid transfer pump.

When the preset quantities of boric acid and reactor makeup water have been added, the batch integrators cause the makeup to stop. This operation may be stopped manually by actuating the makeup stop switch.

If either batch integrator is satisfied before the other has recorded its required total, the pump and valve associated with the integrator which has

been satisfied will terminate the flow. The flow controlled by the other integrator will continue until that integrator is satisfied. In the manual mode, the boric acid flow is terminated first to prevent the piping systems from remaining filled with 7000 to 7700 ppm boric acid solution.

The quantities of boric acid and reactor makeup water injected are totalized by the batch counters, and the flow rates are recorded on strip recorders. Deviation alarms sound for both boric acid and total reactor makeup water if the flow rates deviate from the setpoints.

9.3.4.2.1.4 Boron Thermal Regeneration System

Downstream of the mixed bed demineralizers, the letdown flow can be diverted to the BTRS when boron concentration changes are desired for load follow. After processing by the BTRS, the flow is returned to the letdown flow path at a point upstream of the reactor coolant filter.

The boron concentration measurement system (see Section 7.7) is used to monitor the boron content in the letdown stream before it is diverted to the BTRS for processing or to monitor the adjusted boron content of the letdown stream after it has been treated by the thermal regeneration process.

Storage and release of boron during load-follow operation is determined by the temperature of the fluid entering the thermal regeneration demineralizers. A chiller unit and a group of heat exchangers are employed to provide the desired fluid temperatures at the demineralizer inlets for either storage or release operation of the system. The flow path through the boron thermal regeneration system is different for the boron storage and the boron release operations.

During boron storage, the letdown stream enters the moderating heat exchanger, and from there it passes through the letdown chiller heat exchanger. These two heat exchangers cool the letdown stream prior to its entering the demineralizers. The letdown reheat heat exchanger is valved out on the tube side and performs no function during boron storage operations. The temperature of the letdown stream at the point of entry to the demineralizers is controlled automatically by the temperature control valve which controls the shell side flow to the letdown chiller heat exchanger. After passing through the demineralizers, the letdown enters the moderating heat exchanger shell side where it is heated by the incoming letdown stream before returning to letdown line.

For boron storage, a decrease in the boric acid concentration in the reactor coolant is accomplished by sending the letdown flow at relatively low temperatures to the thermal regeneration demineralizers. The resin, which was depleted of boron at high temperature during a prior boron release operation, is now capable of storing boron from the low temperature letdown stream. Reactor coolant with a decreased concentration of boric acid leaves the demineralizers and is returned to the letdown line.

During the boron release operation, the letdown stream enters the moderating heat exchanger tube side, bypasses the letdown chiller heat exchanger, and passes through the shell side of the letdown reheat heat exchanger. The moderating and letdown reheat heat exchangers heat the letdown stream prior to its entering the resin beds. The temperature of the letdown at the point of entry to the demineralizers is controlled automatically by the temperature control valve which controls the flow rate on the tube side of the letdown reheat heat exchanger. After passing through the demineralizers, the letdown stream enters the shell side of the moderating heat exchanger, passes through the tube side of the letdown chiller heat exchanger, and then goes to the VCT via the reactor coolant filter and letdown line. The temperature of the letdown stream entering the VCT is controlled automatically by adjusting the shell side flow rate on the letdown chiller heat exchanger. Thus, for boron release, an increase in the boric acid concentration in the reactor coolant is accomplished by sending the letdown flow at relatively high temperatures to the thermal regeneration demineralizers. The water flowing through the demineralizers now results in boron being released which was stored by the resin at low temperature during a previous boron storage operation. The boron-enriched reactor coolant is returned to the RCS via the charging system portion of the CVCS.

Although the boron thermal regeneration system is primarily designed to compensate for xenon transients occurring during load follow, it can also be used to handle boron changes during other modes of plant operation. During startup dilution, for example, the resin beds are first saturated, then washed off. This operation continues until the desired dilution in the RCS is obtained. This method of startup serves to reduce the effluents diverted to the boron recycle system.

As an additional function, a thermal regeneration demineralizer can be used as a deborating demineralizer, which can be used to dilute the RCS down to very low boron concentrations toward the end of a core cycle. To make such a bed effective, the effluent concentration from the bed must be kept very low, close to zero ppm boron. This low effluent concentration can be achieved by using fresh resin. Use of fresh resin can be coupled with the normal replacement cycle of the resin, as needed.

9.3.4.2.2 Component Description

Codes and standards applicable to the CVCS are listed in Tables 3.2-1 and 9.3-9. The CVCS is designed and constructed in accordance with the following quality group requirements:

Reactor coolant system boundary valves and piping are quality group A; the letdown, charging, and seal water system and associated containment penetrations are quality group B; the boric acid transfer system is quality group C; and the coolant purification and BTRS are quality group D (augmented) in accordance with Regulatory Guide 1.143 for radioactive waste management systems. The quality group A, B, and C portions are seismic Category I. The entire CVCS is located within seismic Category I structures.

CHARGING PUMPS - Three charging pumps are supplied to inject coolant into the RCS. The two ECCS pumps are of the single speed, horizontal, centrifugal type. These two pumps are 100-percent redundant and are powered from separate Class 1E sources. The third pump, or normal charging pump, is a twelve stage direct drive horizontal centrifugal pump powered from a non-Class 1E source which has a non-safety related trip on a safety injection signal (SIS). The term “centrifugal charging pump” or “CCP” refers to the safety-related ECCS pumps only (PNG05A and PBG05B). The normal charging pump or NCP (PBG04) does not serve an ECCS function (the NCP is tripped by a safety injection signal). All parts in contact with the reactor coolant are fabricated of austenitic stainless steel or other corrosion-resistant material. To prevent leakage to the atmosphere, the ECCS centrifugal pump seals are provided with leakoffs to collect the leakage. There is a minimum flow recirculation line to protect the charging pumps from a closed discharge valve condition.

The charging flow rate is determined from a pressurizer level signal. This signal feeds a flow control valve which is used to modulate flow from the normal charging pump. When operating an ECCS centrifugal charging pump, the flow paths remain the same, but charging flow control is accomplished by modulating a different valve on the discharge side of the ECCS centrifugal pumps. The centrifugal charging pumps also serve as high-head safety injection pumps in the emergency core cooling system. A description of the ECCS charging pump function upon receipt of a safety injection signal is given in Section 6.3.2.2.

BORIC ACID TRANSFER PUMPS - Two 100-percent redundant canned motor pumps are supplied per unit. The pumps are Class 1E devices powered through a qualified isolation device from Class 1E sources with non-Class 1E controls and are shed on a safety injection signal. In the event of loss-of-offsite power, the pumps can be manually loaded on separate Class 1E (diesel backed) sources. The boric acid transfer pumps are normally aligned to supply boric acid to the suction header of the charging pumps. Manual or automatic initiation of the reactor coolant makeup system will start one pump to provide normal makeup of boric acid solution to the suction header of the charging pumps. Mini-flow from this pump flows back to the associated boric acid tank and helps maintain thermal equilibrium. The standby pump can be used intermittently to circulate the boric acid solution through the other tank to maintain thermal equilibrium in this part of the system. The transfer pumps also function to transfer boric acid solution from the batching tank to the boric acid tanks.

Emergency boration, in which 7000 to 7700 ppm boric acid solution is supplied directly to the suction of the charging pumps, can be accomplished by manually starting either or both pumps. This is the preferred emergency boration mode if all components are available, rather than using the ultimate boration capability of the refueling water storage tank. The pumps are located in a heated area to prevent crystalization of the boric acid solution. All parts in contact with the solution are of austenitic stainless steel. An alternate discussion on boration is provided in Appendix 5.4A in conjunction with a discussion of the features of safety-related cold shutdown designs.

CHILLER PUMPS - Two centrifugal pumps circulate the water through the chilled water loop in the BTRS. One pump is normally operated, with the second serving as a standby.

REGENERATIVE HEAT EXCHANGER - The regenerative heat exchanger is designed to recover heat from the letdown flow by reheating the charging flow, which reduces the thermal effects on the charging connections to the reactor coolant loop piping.

The letdown stream flows through the shell of the regenerative heat exchanger while the charging stream flows through the tubes. The unit is constructed of austenitic stainless steel, and is of all-welded construction.

The temperatures of both outlet streams from the heat exchanger are monitored with indication given in the control room. A high temperature alarm is actuated on the main control board if the temperature of the letdown stream exceeds the desired limits.

LETDOWN HEAT EXCHANGER - The letdown heat exchanger cools the letdown stream to the operating temperature of the mixed bed demineralizers. Reactor coolant flows through the tube side of the exchanger while component cooling water flows through the shell side. All surfaces in contact with the reactor coolant are austenitic stainless steel, and the shell is carbon steel.

The low pressure letdown valve, located downstream of the heat exchanger, maintains the pressure upstream of the heat exchanger in a range sufficiently high to prevent flashing downstream of the letdown throttle valves. Pressure indication and high pressure alarm are provided on the main control board.

The letdown temperature control indicates and controls the temperature of the letdown flow exiting from the letdown heat exchanger. The exit temperature of the letdown stream is controlled by regulating the component cooling water flow through the letdown heat exchanger. Temperature indication is provided on the main control board. If the outlet temperature from the heat exchanger is excessive, a high temperature alarm is actuated, and a temperature controlled three-way valve diverts the letdown directly to the reactor coolant filter and bypassing the CVCS demineralizers.

The outlet temperature from the shell side of the heat exchanger is allowed to vary over an acceptable range compatible with the equipment design parameters and required performance of the heat exchanger in reducing letdown stream temperature.

EXCESS LETDOWN HEAT EXCHANGER - The excess letdown heat exchanger cools reactor coolant excess letdown flow. The flow rate is equivalent to the portion of the nominal seal injection flow which flows into the RCS through the reactor coolant pump labyrinth seals.

The excess letdown heat exchanger can be employed either when normal letdown is temporarily out of service to maintain the reactor in operation, to supplement maximum

letdown during the final stages of heatup, or to provide a letdown path from the RCS to the pressurizer relief tank. The letdown flows through the tube side of the unit, and component cooling water is circulated through the shell. All surfaces in contact with reactor coolant are austenitic stainless steel, and the shell is carbon steel. All tube joints are welded.

A temperature detector measures the temperature of the excess letdown flow downstream of the excess letdown heat exchanger. Temperature indication and high temperature alarm are provided on the main control board.

A pressure sensor indicates the pressure of the excess letdown flow downstream of the excess letdown heat exchanger and excess letdown control valve. Pressure indication is provided on the main control board.

Redundant temperature detectors measure the temperature of the letdown flow from the excess letdown heat exchanger to the pressurizer relief tank.

Redundant flow detectors measure the flow rate of the letdown flow from the excess letdown heat exchanger to the pressurizer relief tank.

SEAL WATER HEAT EXCHANGER - The seal water heat exchanger is designed to cool fluid from three sources: reactor coolant pump number 1 seal leakage, reactor coolant discharged from the excess letdown heat exchanger, and miniflow from the charging pumps. Reactor coolant flows through the tube side of the heat exchanger, and component cooling water is circulated through the shell. The design flow rate through the tube side is equal to the sum of the nominal excess letdown flow, maximum design reactor coolant pump seal leakage, and miniflow from one ECCS centrifugal charging pump. The unit is designed to cool the above flow to the temperature normally maintained in the VCT. All surfaces in contact with reactor coolant are austenitic stainless steel, and the shell is carbon steel.

MODERATING HEAT EXCHANGER - The moderating heat exchanger operates as a regenerative heat exchanger between incoming and outgoing streams to and from the boron thermal regeneration demineralizers.

The incoming letdown flow enters the tube side of the moderating heat exchanger. The shell side fluid, which comes directly from the thermal regeneration demineralizers, enters at low temperature during boron storage and high temperature during boron release.

LETDOWN CHILLER HEAT EXCHANGER - During the boron storage operation, the process stream enters the tube side of the letdown chiller heat exchanger after leaving the tube side of the moderating heat exchanger. The letdown chiller heat exchanger cools the process stream to allow the thermal regeneration demineralizers to remove boron from the coolant. The desired cooling capacity is adjusted by controlling the chilled water flow rate passed through the shell side of the heat exchanger.

The letdown chiller heat exchanger is also used during the boron release operation to further cool the liquid leaving the moderating heat exchanger shell side to ensure that its temperature does not exceed that of normal letdown to the VCT.

LETDOWN REHEAT HEAT EXCHANGER - The letdown reheat heat exchanger is used only during boron release operations to heat the process stream. Water used for heating is diverted from the letdown line upstream of the letdown heat exchanger, passed through the tube side of the letdown reheat heat exchanger, and then returned to the letdown stream upstream of the letdown heat exchanger.

VOLUME CONTROL TANK - The VCT provides surge capacity for part of the reactor coolant expansion volume not accommodated by the pressurizer. When the level in the tank reaches the high level setpoint, the remainder of the expansion volume is accommodated by diversion of the letdown stream, upstream of the VCT, to the boron recycle system. The tank also provides a means for introducing hydrogen to the coolant to maintain the required equilibrium concentration of 25 to 50 cc hydrogen (at STP) per kilogram of water and is used for degassing the reactor coolant. It may be used for adding other chemicals to the RCS, and it also serves as a head tank for the charging pumps.

A spray nozzle located inside the tank on the letdown line provides liquid-to-gas contact between the incoming fluid and the hydrogen atmosphere in the tank.

Hydrogen (from the service gas system) is supplied, as required, to the VCT while a remotely-operated vent valve, discharging to the gaseous waste processing system, permits removal of gaseous fission products which are stripped from the reactor coolant and collected in this tank. Relief protection, gas space sampling, and nitrogen purge connections are also provided. The tank can also accept the seal water return flow from the reactor coolant pumps, although this flow normally goes directly to the suction of the charging pumps.

VCT pressure is monitored with indication given in the control room. An alarm is actuated in the control room for high and low pressure conditions. The VCT pressure control valve is automatically closed by the low pressure signal.

Three level channels govern the water inventory in the VCT. Redundant level indication is provided on the main control board from two level channels. Local level indication with a high-low alarm on the main control board is provided from the third channel.

If the VCT level rises above the normal operating range, one level channel provides an analog signal to the proportional controller which modulates the three-way valve downstream of the reactor coolant filter to maintain the VCT level within the normal operating band. The three-way valve can split letdown flow so that a portion goes to the boron recycle system and a portion to the VCT. The controller would operate in this fashion during a dilution operation when reactor makeup water is being fed to the VCT from the reactor makeup control system.

If the modulating function of the channel fails and the VCT level continues to rise, the high level alarm will alert the operator to the malfunction, and the full letdown flow is diverted to the recycle hold-up tank.

During normal power operation, a low level in the VCT initiates automatic makeup which injects a preselected blend of boric acid solution and reactor makeup water into the charging pump suction header. When the volume control tank level is restored to normal, automatic makeup stops.

If the automatic makeup fails or is not aligned for operation and the tank level continues to decrease, a low level alarm is actuated. Manual action may correct the situation, or if the level continues to decrease, a low-low signal from either of the two redundant level channels opens its associated stop valve in the RWST supply line, and closes its associated stop valve in the VCT outlet line. For a description of the VCT level controls, refer to Section 7.6.11.

BORIC ACID TANKS - The combined BAT capacity is sized to store sufficient boric acid solution for refueling plus enough for a cold shutdown from full-power operation immediately following refueling with the most reactive control rod not inserted.

The concentration of boric acid solution in storage is maintained between 7000 and 7700 ppm boron. Periodic manual sampling and corrective action, if necessary, assure that these limits are maintained. Therefore, measured amounts of boric acid solution can be delivered to the reactor coolant to control the prevailing boron concentration.

A temperature sensor provides the temperature measurement of the contents of each tank. Temperature indication, as well as high and low temperature alarms, are provided on the main control board.

Two level detectors indicate the level in each boric acid tank. Level indication with high, low, low-low, and empty level alarms is provided on the main control board. The high alarm indicates that the BAT may soon overflow. The low alarm warns the operator to start makeup to the BAT. The low-low alarm is set to indicate the minimum level of boric acid in the BAT to ensure that sufficient boric acid is available for a cold shutdown with one stuck rod. The empty level alarm is set to give warning of loss of pump suction.

BATCHING TANK - The batching tank is used for mixing a makeup supply of boric acid solution for transfer to the boric acid tanks.

A local sampling point is provided for verifying the solution concentration prior to transferring it out of the tank. The tank is provided with an agitator to improve mixing during batching operations and a steam jacket for heating the boric acid solution.

CHEMICAL MIXING TANK - The primary use of the chemical mixing tank is in the addition to the RCS of caustic solutions for pH control, hydrazine solution for oxygen

scavenging, chemicals for corrosion products oxidation during a refueling shutdown, and other chemicals as necessary.

CHILLER SURGE TANK - The chiller surge tank handles the thermal expansion and contraction of the water in the chiller loop. The surge volume in the tank also acts as a thermal buffer for the chiller. The fluid level in the tank is monitored with level indication, and high and low level alarms are provided on the main control board.

MIXED BED DEMINERALIZERS - Two flushable mixed bed demineralizers assist in maintaining reactor coolant purity. A lithium form cation resin and hydroxyl-form anion resin are charged into the demineralizer(s) in support of normal plant operations. The anion resin is converted to the borate form in operation. Both types of resin remove fission and corrosion products. The resin bed is designed to reduce the concentration of ionic isotopes in the purification stream, except for cesium, yttrium, and molybdenum, by a minimum factor of 10.

Non-lithiated resin can be used in a mixed bed deminerlizer in support of plant shutdown conditions for RCS purification and filtration needs. The use of non-lithiated resin for plant shutdown conditions may extend the useful life of the lithiated mixed resin and cation bed resin for normal plant operation.

Each demineralizer has more than sufficient capacity for one core cycle with 1 percent of the rated core thermal power being generated by defective fuel rods. One demineralizer is normally in service with the other in standby.

A temperature sensor monitors the temperature of the letdown flow downstream of the letdown heat exchanger. If the letdown temperature exceeds the maximum allowable resin operating temperature (approximately 140°F), a three-way valve is automatically actuated so that the flow bypasses the demineralizers. Temperature indication and high alarm are provided on the main control board. The air-operated, three-way valve failure mode directs flow to the VCT via the reactor coolant filter.

CATION BED DEMINERALIZER - A flushable cation resin bed in the hydrogen form is located downstream of the mixed-bed demineralizers and is used intermittently to control the concentration of Li-7 (pH control) in the reactor coolant system. Its size is based upon the estimated production of Li-7 in the reactor core region due to the $B^{10} \rightarrow (n\alpha) \rightarrow Li^7$ reaction during base load operation. The demineralizer also has sufficient capacity to maintain the cesium-137 concentration in the coolant below 1.0 μCi/cc with 1 percent defective fuel. The resin bed is designed to reduce the concentration of ionic isotopes, particularly cesium, yttrium, and molybdenum, by a minimum factor of 10.

The demineralizer has more than sufficient capacity for one core cycle with 1 percent of the rated core thermal power being generated by defective fuel rods.

THERMAL REGENERATION DEMINERALIZERS - The function of the thermal regeneration demineralizers is to store the total amount of boron that must be removed

from the RCS to accomplish the required dilution during a load cycle in order to compensate for xenon buildup resulting from a decreased power level. Furthermore, the demineralizers must be able to release the previously stored boron to accomplish the required boration of the reactor coolant during the load cycle in order to compensate for a decrease in xenon concentration resulting from an increased power level.

The thermally reversible ion storage capacity of the resin applies only to borate ions. The capacity of the resin to store other ions is not thermally reversible. Thus, during boration, when borate ions are released by the resin, there is no corresponding release of the ionic fission and corrosion products stored on the resin.

The thermal regeneration demineralizer resin capacity is directly proportional to the solution boron concentration and inversely proportional to the temperature. Further, the differences in capacity as a function of both boron concentration and temperature are reversible. For the 50°F to 140°F temperature cycle, this reversible capacity varies from the beginning of a core cycle to the end of core life by a factor of about 2.

The demineralizers are of the type that can accept flow in either direction. The flow direction during boron storage is therefore always opposite to that during release. This provides faster response when the beds are switched from storage to release and vice versa than would be the case if the demineralizers could accept flow in only one direction.

Temperature instrumentation is provided upstream of the thermal regeneration demineralizers to control the temperature of the process flow. During boron storage operations, it controls the flow through the shell side of the letdown chiller heat exchanger to maintain the process flow at 50°F as it enters the demineralizers. During boron release operations, it controls the flow through the tube side of the letdown reheat heat exchanger to maintain the process flow at 140°F as it enters the demineralizers. Temperature indication and a high temperature alarm are provided on the main control board.

An additional temperature instrument is provided to protect the demineralizer resins from a high temperature condition. On reaching the high temperature set point, an alarm is sounded on the main control board, and the letdown flow is diverted to the VCT from a point upstream of the mixed bed demineralizers.

Failure of the temperature controls resulting in hot water flow to the demineralizers would result in a release of boron stored on the resin with a resulting increase in reactor coolant boron concentration and increased margin for shutdown. If the temperature of the resin rises significantly above 140°F, the number of ion storage sites on the resin will gradually decrease, thus reducing the capability of the resin to remove boron from the process stream. Degradation of ion-removal capability will occur for temperatures of approximately 160°F and above. The extent of the degradation and rate at which it will occur depend upon the temperature experienced by the resin and the length of time that the resin experiences this elevated temperature.

Failure of the temperature control system resulting in cold water flow to the demineralizers would result in storage of boron on the resin and reduction of the reactor coolant boron concentration. The amount of reduction in the reactor coolant boron concentration is limited by the capacity of the resin to remove boron from the water. As the boron concentration is reduced, negative reactivity would be added using boric acid system makeup or using control rods to maintain the power level. If the rods were to reach the rod insertion limit, the low-low alarm would be actuated informing the operator that actions are necessary in order to maintain the capability of shutting the reactor down with control rods alone (see Section 7.7.1.3.3).

REACTOR COOLANT FILTER - The reactor coolant filter is located in the letdown line upstream of the VCT. The filter collects resin fines and particulates from the letdown stream. The nominal flow capacity of the filter is greater than the maximum letdown flow rate. A differential pressure indicator monitors the pressure drop across the reactor coolant filter and provides a high differential pressure alarm on the main control board.

SEAL WATER INJECTION FILTERS - Two seal water injection filters are located in parallel in a common line to the reactor coolant pump seals; they collect particulate matter that could be harmful to the seal faces. Each filter is sized to accept flow in excess of the normal seal water flow requirements.

A differential pressure indicator monitors the pressure drop across each seal water injection filter and gives local indication with high differential pressure alarm on the main control board.

Redundant safety related flow monitoring is provided downstream of seal water injection filters.

SEAL WATER RETURN FILTER - This filter collects particulates from the reactor coolant pump seal water return and from the excess letdown flow. The filter is designed to pass the sum of the excess letdown flow and the maximum design leakage from all reactor coolant pumps.

A differential pressure indicator is provided to show the differential pressure across the seal water return filter.

BORIC ACID FILTER - The boric acid filter collects particulates from the boric acid solution being pumped from the boric acid tanks by the boric acid transfer pumps. The filter is designed to pass the design flow of two boric acid transfer pumps operating simultaneously.

A differential pressure indicator is provided to show the differential pressure across the boric acid filter.

LETDOWN THROTTLE VALVES - Three letdown throttle valves are provided to reduce the letdown pressure from reactor conditions and to control the flow of reactor coolant

leaving the RCS. The throttle valves are placed into or out of service by remote operation of their respective isolation valves. Two of the throttle valves are designed for a normal letdown flow of 75 gpm, and the third throttle valve is designed for 45 gpm. A bypass line around the 45 gpm throttle valve with two manual control valves is also installed to allow greater letdown flow during lower modes of plant operation (modes 4, 5 and 6). During normal power operation the 45 gpm throttle valve, a 75 gpm throttle valve or the 45 gpm and one of the 75 gpm throttle valves may be used to attain the desired letdown flowrate. Any combination of the three throttle valves and/or the manual bypass line may be used for flow control during lower modes of plant operation (modes 4, 5 and 6), such as plant startup, when maximum letdown is desirable, provided the maximum letdown flowrate of 120 gpm is not exceeded. Each throttle valve consists of an assembly which provides for permanent pressure loss without recovery, and is made of austenitic stainless steel or other adequate corrosion resistant material.

A flow monitor provides indication in the control room of the letdown flow rate and an alarm to indicate unusually high flow.

A low pressure letdown controller located downstream of the letdown heat exchanger controls the pressure upstream of the letdown heat exchanger to prevent flashing of the letdown liquid. Pressure indication and high pressure alarm are provided on the main control board.

CHILLER - The chiller is located in a chilled water loop containing a surge tank, chiller pumps, the letdown chiller heat exchanger, piping, valves, and controls.

The purpose of the chiller is twofold:

a. To cool down the process stream during storage of boron on the resin.

b. To maintain an outlet temperature from the BTRS at or below 115°F during release of the boron.

VALVES - Where functional requirements permit, elastomere diaphragm-type valves or packless globe valves are used to essentially eliminate leakage to the atmosphere. All packed valves which are larger than 2 inches and which are designated for radioactive services may be provided with a stuffing box and lantern leakoff connections.

All control (modulating) and three-way valves may be provided with stuffing box and leakoff connections or are totally enclosed. Leakage to the atmosphere is essentially zero for these valves. Basic material of construction is stainless steel for all valves which handle radioactive liquid or boric acid solutions.

All active, power-operated valves which are required to realign the CVCS for emergency core cooling, to isolate the containment, or are utilized as part of the safety-related cold shutdown design are energized from Class 1E sources.

Normal letdown, purification, reactor makeup control, and BTRS power-operated valves, which are not required for emergency core cooling or containment isolation, fail to the safe position and are powered from non-Class 1E sources. However, in the event of a loss of offsite power, selected valves in the boric acid transfer system can be manually loaded on a Class 1E (diesel-backed) bus.

Relief valves are provided for lines and components that might be pressurized above design pressure by improper operation or component malfunction.

PIPING - All CVCS piping that handles radioactive liquid is austenitic stainless steel.

9.3.4.2.3 System Operation

Operation of the CVCS is described for the various phases of reactor plant operation presented below.

9.3.4.2.3.1 Plant Startup

Plant startup is defined as the operations which bring the reactor from the cold shutdown condition to normal, no-load operating temperature and pressure.

Two basic methods exist by which the plant is started following a Mode 6, Mode 5 (loops filled) or a Mode 5 (loops not-filled) condition.

<u>Method 1 - Solid Plant Operations</u>

The pressurizer is filled to 100% at normal atmospheric pressure or at a vacuum. Then subsequent static and dynamic venting is performed, or

<u>Method 2, A Steam Bubble is drawn in the Pressurizer without going solid</u>

The plant is vacuum filled to some level in the pressurizer where adequate mass exists that a steam bubble may be drawn without reactor coolant pumps operating.

Once a bubble is drawn in the pressurizer with reactor coolant pumps operating subsequent plant startup is the same for both methods.

Under both conditions the Residual Heat Removal System(s)(RHR) is/are in service providing shutdown cooling. A charging pump is placed in service, or is currently operating, to provide Reactor Coolant System (RCS) makeup and Reactor Coolant Pump (RCP) seal injection, when RCS level is changed. The Chemical Volume and Control System (CVCS) will control RCS level by adjustments in charging and letdown flow, in auto or manual mode. Letdown is provided via RHR (HCV-128) and/or normal letdown off RCS loop 3 crossover leg. Normal letdown may be through any combination of the letdown throttle valves and/or the manual bypass line provided the total flow is maintained below the maximum letdown flow of 120 gpm. The CVCS is utilized to

periodically provide a cleanup flowpath via demineralizers as well as fill the RCS with clean borated water. The makeup water will come from the RWST or the reactor makeup water storage tank that is blended to a concentration at or above the current RCS boron concentration.

Method 1

When startup commences utilizing Solid Plant operations the RCS level is initially greater than that required to meet the RHR pump minimum NPSH. When RCS fill is initiated pressure is either at atmospheric or at a vacuum. If the steam generator loop seal has been broken or forced draining was utilized air is trapped in the steam generator U-tubes. The main difference between filling with a vacuum vice atmospheric pressure is the reduced number of RCP starts required to sweep the air out of the Steam Generator U-tubes.

Filling with the RCS at atmospheric pressure; Once solid plant conditions are met, static venting occurs at strategic RCS locations (i.e.: vessel head and at the pressurizer). With static venting complete, pressure is increased for RCP starts to sweep the air out of the U-tubes, then venting occurs again. Multiple starts are required to ensure the plant is solid with all the air out of the tubes. With a vacuum fill, water is drawn up into the U-tubes as RCS level is raised, and when solid plant conditions exist, a static vent is performed then pressure increased to start the RCP.

During solid plant operations the RCS is cold with pressure being controlled with charging (makeup) and letdown. For stable plant pressure, charging and letdown are balanced. To increase or decrease primary plant pressure, charging and letdown are adjusted for either a mass addition or reduction depending upon current needs. Special precautions are exercised to ensure that an overpressurization transient does not occur. Overpressure protection is discussed in Section 5.2.2.

Once solid plant conditions are established with RCPs operating, chemical treatment (deoxygenation) is performed, as required prior to the RCS reaching 250°F. Depending upon the chemical treatment utilized, the mixed bed demineralizers in the CVCS system may have to be bypassed to avoid driving lithium off the bed and replacing it with ammonia which is the case with hydrazine (chemical treatment)/oxygen reaction.

After oxygen scavenging is complete, the pressurizer spray valves are closed with pressurizer heaters energized to allow the pressurizer to heat up independently of the RCS loops which are being maintained with RHR. Once the saturation temperature of the current RCS pressure is reached in the pressurizer, bubble formation begins. To draw the bubble in the pressurizer, either charging is reduced or letdown is increased to lower the level in the pressurizer to the non-load level. At this point RCS pressure will be maintained utilizing the combination of pressurizer heaters and spray valves.

Method 2

The second method of plant startup utilizes vacuum fill and drawing a steam bubble without going solid and no RCPs operating. The same initial conditions existing with RHR in service providing shutdown cooling and CVCS in service providing makeup and RCP seal injection.

With this method the RCS is vacuum filled in the same method as previously stated. A level, depending upon entry conditions (i.e.: status of the S/G U-tubes), is established in the RCS or pressurizer and a vacuum is drawn. With a vacuum established, level is raised into the pressurizer to approximately 40%. The pressurizer will then be chemically treated for oxygen. Charging and letdown, via RHR, are in service so that level fluctuations may be accounted for.

At this point bubble formation will begin. With a vacuum in the pressurizer, the heaters are energized to allow bubble formation at a lower temperature. Once the bubble is drawn pressurizer pressure is maintained with auxiliary spray flow and heaters. The same precautions exist for an overpressurizartion transient that did with solid plant operations. However pressure control with a bubble provides a cushion that dampens plant response to potential pressure transients. The pressurizer cushion (bubble) provides easier pressure control with slower response rates.

Spray flow is now minimized so that the RCS is allowed to pressurize for RCP start. At approximately 100 psig the RCS is statically vented at the vessel head to ensure there are no trapped gasses. Pressure is allowed to increase to the minimum allowed for RCP operation, approximately 250 psig. Once RCP's have been started, chemical treatment of the RCS is performed. After chemical treatment of the RCS is complete normal pressurizer spray flow is restored to reduce the spray nozzle DT.

At this point in the startup the same conditions exist in the RCS for both methods; the RCS is approximately 180°F, a steam bubble exists in the pressurizer, RCS pressure is controlled via normal spray and heaters, and RCPs are in operation.

Subsequently the RCS is allowed to heat up using reactor coolant pump heat to the point where RHR may be removed from service. Once RHR is removed from service and placed in standby lineup, RCS temperature is maintained within the heat up limitations using the secondary side to dump steam to the condenser or to atmosphere. As RCS pressure is allowed to increase normal letdown flow is attained and placed in auto. Minor adjustments in charging flow are required to maintain pressurizer level at no-load value.

As RCS temperature and pressure are increased towards normal operating temperature (NOT) and pressure (NOP) various Engineered Safety Systems are placed in their respective standby lineups. Since shutdown boron concentrations are much higher than that required at NOP/NOT the RCS boron concentration is reduced to a limit not to exceed that required for adequate shutdown margin.

Once NOP/NOT is reached and a chemical analysis confirms that RCS water quality, boron, and hydrogen concentrations are within specifications, the approach to criticality

is commenced. For the approach to criticality a critical boron concentration determination is made based upon estimated critical control rod height. A subsequent boron concentration change is made to this value. Criticality is then achieved by control rod withdrawal. Alternatively, control rods may be withdrawn to the desired critical control rod height, and then criticality achieved by dilution of the boron.

Following criticality further adjustments in boron concentration are made to compensate for desired control rod position, power defect, and the build up of xenon while maintaining the concentration above that required for adequate shutdown margin.

9.3.4.2.3.2 Normal Operation

Normal operation includes operation at steady power (base load) level, load follow operation, and hot standby.

BASE LOAD - At a constant power level, the rates of charging and letdown are dictated by the requirements for seal water to the reactor coolant pumps and the normal purification of the reactor coolant system. One charging pump is employed, and the flow is controlled automatically from pressurizer level. The only adjustments in boron concentration are those necessary to compensate for core burnup.

These adjustments are made at infrequent intervals (twice per week) to maintain the maneuvering band of the rod control groups within their allowable limit. Rapid variations in power demand will be accommodated by control rod movement. If variations in power level occur, and the new power level is sustained for long periods, some adjustment in boron concentration may be necessary to ensure the preservation of the shutdown margin.

During normal operation, the letdown flow is 75 gpm, and one mixed bed demineralizer is in service. Reactor coolant samples are taken at frequent intervals to check boron concentration, water quality, pH, and activity level. The normal charging pump flow is controlled by BGFCV0124 via the pressurizer water level at the set point programmed for a prevailing reactor coolant average temperature. During normal operation with maximum purification, the letdown flow is 120 gpm. The charging flow control valve (BGFCV0121) is modulated by pressurizer water level during safety-related ECCS centrifugal pump operation.

LOAD FOLLOWING - The most important source of information available to the plant operator that enables him to determine whether dilution or boration is necessary is the position of the control rods within the maneuvering band. If, for example, the control rods are moving down into the core, and are approaching the bottom of the maneuvering band, the operator must borate the RCS and manually withdraw the control rods. If not, the control rods will move into the core beyond the rod insertion limit. The operator may dilute the RCS to keep the rods below or at the top of the maneuvering band which insures capability of immediate return to full power. With the control rods above the top of the maneuvering band, the reactor cannot return to full power immediately; however,

the reactor can return to some lower power level immediately and then reach full power at some rate determined by the xenon burnout transient.

To minimize the boration and dilution operations, the reactivity worth in the maneuvering band can be used. This is accomplished by positioning the control rods properly in anticipation of xenon transients. For example, prior to a load reduction the control rods should be moved toward the bottom of the maneuvering band so that when the reactor load is reduced by lowering the control rods, and xenon builds up, the control rods can be manually moved upward within the maneuvering band to the extent that dilution of the RCS does not compensate for the total xenon buildup.

To optimize operation during a xenon buildup transient, the RCS is diluted by an amount that will allow the control rods to be manually moved to the top of the maneuvering band when the reactor power is to be increased. During the load increase, and the xenon burnout transient, boration of the RCS should only be done to the extent that the rods move to the bottom of the maneuvering band. This method of operation will reduce the required boration and dilution of the RCS by an amount corresponding to the reactivity worth of the maneuvering band. It will also make load following possible beyond the point in the core life where the xenon transient can be completely compensated for by boration and dilution of the RCS.

Operation of the BTRS is automatic. A master switch is provided which puts the BTRS in the right mode of operation for release or storage of boron on the resin beds. This switch performs the following functions for storage (RCS dilution):

a. Aligns the proper flow path for dilution.

Valves open	Valves closed	Valves modulating
BGHV7054	BGHV8245	BGTCV0386
BGUV7002A	BGUV7040	
BGUV7002B	BGUV7041	
BGUV7056	BGTCV381A	
Deleted	BGUV7057	
BGUV7045	BGUV7046	
BGUV7022		

b. Shuts off the letdown reheat heat exchanger tube side flow which puts this heat exchanger out of operation (closes BGTCV0381A).

c. Transfers control of BGTCV0386, the control valve at the letdown chiller heat exchanger shell side outlet, to BGTCY0381B which is located

between the letdown reheat heat exchanger and the BTRS demineralizers. The temperature set point is 50°F.

d. Starts chiller and chiller pump.

For release (RCS boration), the master switch performs the following functions:

a. Aligns the proper flow path for boration.

Valves open	Valves closed	Valves modulating
BGHV7054	BGHV8245	BGTCV0386
BGUV7041	BGUV7002A	BGTCV0381A
BGUV7057	BGUV7002B	Deleted
Deleted	BGUV7056	
BGUV7046	BGUV7045	
BGUV7040	BGUV7022	

b. Energizes the control of BGTCV0381A for the tube side flow rate to the letdown reheat heat exchanger by a signal from BGTCY0381A located between this heat exchanger and the BTRS demineralizers. The temperature set point is 140°F.

c. Transfers control of the control valve BGTCV0386 at letdown chiller heat exchanger shell side outlet to BGTCY0386 located in the line leading from the moderating heat exchanger to the reactor coolant filter. The temperature set point is 115°F.

d. Starts chiller and chiller pump.

The BTRS is put into operation as follows:

For dilution of the RCS (storage):

a. Cool down the chiller loop to about 40°F. This is not a requirement, but it will provide a faster cooldown transient of the BTRS.

b. Put the master switch in the dilute position.

c. Control the rate of dilution by positioning 3-way valve BGHCV0387. The flow rate through the BTRS is dictated by the desired dilution rate of the RCS.

For boration of the RCS (releases):

a. Put the master switch in the boration position.

b. Control the rate of boration by positioning 3-way valve BGHCV0387. The flow rate through the BTRS is dictated by the desired boration rate of the RCS.

The BTRS is shut down by placing the master switch in the off position.

Several resin beds in the BTRS can be used as deborating demineralizers, which toward the end of the core life are used to dilute the RCS down to very low boron concentrations. To make such beds effective, the effluent concentration from the beds must be kept very low, close to zero ppm. This can be achieved by using fresh resin. This should be coupled with the normal replacement cycle of the resin beds.

HOT SHUTDOWN - If required for periods of maintenance, or following spurious reactor trips, the reactor can be held subcritical, but with the capability to return to full power within the period of time it takes to withdraw the control rods. During this hot shutdown, the average temperature is maintained at no-load T-avg by initiating steam dumping to provide residual heat removal or at later stages by running the reactor coolant pumps to maintain the system temperature.

Following shutdown, xenon buildup occurs and increases the degree of shutdown; i.e., initially, all control rods are inserted, and the core is maintained at a minimum of 1 percent $\Delta k/k$ subcritical. The effect of the xenon buildup is to increase this value to a maximum of about 4 percent $\Delta k/k$ at about 8 hours following shutdown from equilibrium full power conditions.

If a return to power is anticipated, the reactor is taken critical by withdrawing the control banks. The xenon transient is followed by rod movement and boration, as necessary, to maintain the control banks above the rod insertion limit.

If a prolonged shutdown is required, the reactor coolant is borated to the hot standby, xenon-free value and the control rods are inserted.

9.3.4.2.3.3 Reactor Cooldown

Reactor cooldown is the operation which takes the reactor from hot standby to cold shutdown conditions (reactor is subcritical by at least 1 percent $\Delta k/k$ and Tavg 200°F).

Normal Cold Shutdown

Before initiating a cold shutdown, the RCS hydrogen concentration is lowered by reducing the volume control tank overpressure, by replacing the volume control tank

hydrogen atmosphere with nitrogen, and by continuous purging to the gaseous radwaste system.

Before cooldown and depressurization of the reactor plant is initiated, the reactor coolant boron concentration is increased to the cold shutdown value. Ater the boration is completed and reactor coolant samples verify that the concentration is correct, the operator resets the Reactor Makeup Control System for leakage and system contraction makeup at the shutdown reactor coolant boron concentration.

Contraction of the coolant during cooldown of the RCS results in actuation of the pressurizer level control to maintain normal pressurizer water level. The charging flow is increased, relative to letdown flow, and results in a decreasing volume control tank level. The volume control tank level controller automatically initiates makeup to maintain the inventory. Depressurizaton is performed by cooling the vapor space of the pressurizer with spray flow from an RCS loop with an operating reactor coolant pump.

Prior to placing the RHRS in service, letdown may be provided through any combination of the letdown throttle valves and/or the manual bypass line provided the letdown flow is maintained below the maximum letdown flow of 120 gpm. After the RHRS is placed in service and the reactor coolant pumps are shut down, further cooling of the pressurizer liquid is accomplished by charging through the auxiliary spray line from the outlet of the CVCS regenerative heat exchanger. Coincident with plant cooldown, a portion of the reactor coolant flow is diverted from the RHRS to the CVCS for cleanup.

If required, operation of the mixed-bed demineralizers and gas stripping are started in advance of a planned shutdown; demineralization of ionic radioactive impurities and stripping fission gases reduce the reactor coolant activity level to permit personnel access for maintenance or refueling operations.

Safety-related Cold Shutdown

It is expected that the portions of the CVCS that are relied upon to perform reactor coolant system (RCS) purification, boration, letdown and depressurization operations, following an event that requires eventual cooldown and long term cooling, will function in the normal manner. Additional safety related features have been designed and incorporated into the CVCS design to ensure that certain functions relied upon to take the reactor from the hot standby mode to the cold shutdown mode will be available; in other words, the safety grade features have been provided to augment normal shutdown features should equipment availability become a concern.

The following discussion describes the functioning of the CVCS using only safety-related equipment. Before cooldown and depressurization of the RCS is initiated, the RCS boron concentration is increased to the cold shutdown value. Borated water from the RWST is delivered to the RCS through the Emergency Core Cooling System (ECCS) cold leg injection lines via the boron injection header and to the RCS through the reactor coolant pump (RCP) seals via seal injection lines. Charging flow is provided by the

ECCS centrifugal charging pumps. Should RCS inventory letdown be required, this function can be accomplished by releasing RCS fluid to the pressurizer relief tank (PRT) via the excess letdown heat exchanger.

Following the initial RCS boration/letdown operation, the RCS is depressurized by venting the pressurizer to the PRT through the pressurizer power-operated relief valves (PORVs). RCS pressure control will be maintained by using the ECCS centrifugal charging pumps to provide RCS inventory control/makeup in conjunction with the use of the PORVs.

In the event normal charging and letdown paths are not available, RCS boration and inventory control functions will be maintained by utilizing redundant safety grade paths with the necessary throttling capability.

Appendix 5.4A provides a systems integrated discussion on safe shutdown/cold shutdown.

9.3.4.2.3.4 Emergency Boration

If emergency boration is required to achieve and maintain a safe shutdown, as described in Section 7.4, then the redundant ECCS charging pumps can take suction from either the RWST or from the BAT via the boric acid transfer pumps and discharge either through the RCP seals, the charging line, or the boron injection header.

The preferred mode, if offsite power is available, is the normal shutdown operation described in Section 9.3.4.2.3.3. This mode utilizes the boric acid transfer system and normal seal injection and charging. If offsite power is unavailable, then the RWST and the boron injection path are used to borate the core. Further, if the RWST is rendered unavailable, then the boric acid transfer pumps can be loaded on the diesel and appropriate valves opened to provide suction to the ECCS charging pumps.

Sufficient flow can be delivered, either through the boron injection path or through the reactor coolant pump seals, to borate the reactor coolant system to a cold shutdown concentration. In either case, the flow can be throttled using jog control switches to permit orderly matching of the letdown and RCS shrinkage to the charging flow. The ECCS charging pumps are protected with open miniflow recirculation lines during low flow operations. The emergency letdown path to the PRT can also be throttled using operator interface modules (BB-HCI-8157A,B).

9.3.4.2.3.5 Emergency Core Cooling

The charging portion of the CVCS (PBG05A, PBG05B) plays an integral part in the emergency core cooling requirements for accidents involving small breaks or inadvertent valve lifting in the main steam or feedwater systems.

The ECCS centrifugal charging pumps deliver borated water at the prevailing RCS pressure to the cold legs of the RCS. During the injection mode, the ECCS charging pumps take suction from the refueling water storage tank.

The delivery of the boric acid provides negative reactivity to counteract the positive reactivity caused by the system cooldown.

The safety injection function of the CVCS is automatically actuated by a safety injection signal (SIS). For a RCS equivalent pipe break opening of 3/8-inch (liquid service) diameter or less, the charging system can maintain the pressurizer level at the normal operating level and pressure. Therefore, the emergency core cooling system would not be automatically actuated, and is not required. Details of the response by the CVCS are presented in Section 6.3.

9.3.4.3 Safety Evaluation

Safety evaluations are numbered to correspond to the safety design bases in Section 9.3.4.1.1.

SAFETY EVALUATION ONE - The safety-related portions of the CVCS are located in the reactor and auxiliary buildings. These buildings are designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other appropriate natural phenomena. Sections 3.3, 3.4, 3.5, 3.7(B), and 3.8 provide the bases for the adequacy of the structural design of these buildings.

SAFETY EVALUATION TWO - The safety-related portions of the CVCS are designed to remain functional after an SSE. Sections 3.7(B).2 and 3.9(B) provide the design loading conditions that were considered. Sections 3.5, 3.6, and 9.5.1 provide the hazards analyses to assure that a safe shutdown, as outlined in Section 7.4, can be achieved and maintained.

SAFETY EVALUATION THREE - The safety-related portions of the CVCS are completely redundant and, as indicated by Table 9.3-10, no single failure will compromise the system's safety functions. All vital power can be supplied from either onsite or offsite power systems, as described in Chapter 8.0.

SAFETY EVALUATION FOUR - The CVCS is initially tested with the program given in Chapter 14.0. Periodic inservice functional testing is done in accordance with Section 9.2.2.4.

Section 6.6 provides the ASME Boiler and Pressure Vessel Code, Section XI requirements that are appropriate for the CVCS.

SAFETY EVALUATION FIVE - Section 3.2 delineates the quality group classification and seismic category applicable to the safety-related portion of this system and supporting systems. Table 9.3-9 shows that the components meet the design and fabrication codes

given in Section 3.2. Except for the control functions for the BAT system, all the power supplies and control functions necessary for safe function of the CVCS are Class 1E, as described in Chapters 7.0 and 8.0. The controls for the BAT system are only required when the RWST is rendered inoperable, and the design of the control system is adequate for this situation.

SAFETY EVALUATION SIX - Section 9.3.4.2.1 describes provisions made to identify and isolate leakage or malfunction and to isolate the nonsafety-related portions of the system. See also Section 15.4.6 for discussion of boron dilution accident.

SAFETY EVALUATION SEVEN - Sections 6.2.4 and 6.2.6 provide the safety evaluation for the system containment isolation arrangement and testability.

SAFETY EVALUATION EIGHT - Any time that the plant is critical at power, the quantity of boric acid retained and ready for injection is always equal to or greater than that quantity required for normal cold shutdown, assuming that the control assembly of greatest worth is in its fully withdrawn position. This quantity always exceeds the quantity of boric acid required to bring the reactor to hot shutdown and to compensate for subsequent xenon decay. An adequate quantity of boric acid is available in either the refueling water storage tank or the boric acid tanks to achieve cold shutdown.

When the reactor is subcritical (i.e., during cold shutdown, hot shutdown, hot standby) the source range nuclear instrumentation continuously monitors the neutron flux to detect any indication of an inadvertent boron dilution transient. Upon the detection of a sufficient increase in the neutron flux during any of the aforementioned modes of operation, an alarm is sounded to alert the operator, and valve movement to terminate the dilution and start boration is automatically initiated. These automatic corrective actions prevent the core from becoming critical. (See also Section 15.4.6 for discussion of boron dilution accident.) The rate of boration, with a single boric acid transfer pump operating, is sufficient to take the reactor from full power operation to 1 percent shutdown in the hot condition, with no rods inserted, in less than 90 minutes. In less than 90 additional minutes, enough boric acid can be injected to compensate for xenon decay, although xenon decay below the equilibrium operating level will not begin until approximately 25 hours after shutdown. Additional boric acid is employed if it is desired to bring the reactor to cold shutdown conditions.

Three separate and independent flow paths are available for reactor coolant boration; i.e., the charging line, the reactor coolant pump seal injection lines, and the boron injection header. A single active failure does not result in the inability to borate the RCS.

If the normal charging line is not available, charging to the RCS may be continued via reactor coolant pump seal injection at the rate of approximately 5 gpm per pump. At the charging rate of 20 gpm (5 gpm per reactor coolant pump), approximately 5.0 hours are required to add enough 7000 to 7700 ppm boric acid solution to counteract xenon decay, although xenon decay below the full power equilibrium operating level will not begin until approximately 25 hours after the reactor is shut down.

As backup to the normal boric acid supply, the operator can align the refueling water storage tank outlet to the suction of the charging pumps.

Should the normal charging and RCP seal injection paths not be available for boration or makeup, redundant safety related flow paths with necessary throttling capability are provided by the ECCS cold leg injection headers via the boron injection header.

The CVCS is capable of borating the RCS to cold shutdown concentration at a rate that is compatible with meeting the objectives of the cold shutdown design, described in Appendix 5.4A. (Letdown to accommodate boration is also discussed in Appendix 5.4A.) The CVCS is also capable of providing sufficient borated water from the refueling water storage tank to make up for primary shrinkage due to cooling or RCS inventory discharged during cooldown.

Since inoperability of a single component does not impair the ability to meet boron injection requirements, plant operating procedures allow the components to be temporarily out of service for repairs. However, with an inoperable component, the ability to tolerate additional component failure is limited. Therefore, FSAR Chapter 15 and Technical Specifications require immediate action to effect repairs of an inoperable component, restrict permissible repair time, and require demonstration of the operability of the redundant component.

SAFETY EVALUATION NINE - As discussed in Section 9.3.4.2, the CVCS is capable of making up for a small RCS leakoff up to approximately 120 gpm, using one ECCS centrifugal charging pump, and still maintaining seal injection flow to the reactor coolant pumps. This also allows for a minimum RCS cooldown contraction. This is accomplished with the letdown isolated.

SAFETY EVALUATION TEN - Section 6.3 provides the safety evaluation for the emergency core cooling operation of the CVCS. Portions of the CVCS are relied upon for safe shutdown and accident mitigation.

The failure mode and effects analysis summarized in Table 9.3-10 demonstrates that single active component failures do not compromise the CVCS safe shutdown functions of boration and makeup. This analysis also shows that single failures occurring during CVCS operation do not compromise the ability to prevent or mitigate accidents. The capabilities are accomplished by a combination of suitable redundancy, instrumentation for indication and/or alarm of abnormal conditions, and relief valves to protect piping and components against malfunctions.

Portions of the CVCS are also relied upon to provide safety-related boration and makeup. The capability of the CVCS to perform in conjunction with other systems of the cold shutdown design is presented in the Table 5.4A-3.

The CVCS shares components with the ECCS and containment isolation functions. These safeguard functions of the CVCS are addressed in Chapter 6.0.

SAFETY EVALUATION ELEVEN - Appendix 5.4A demonstrates how cold shutdown, including the function of boration, is achieved with the use of only safety-related equipment.

9.3.4.4 Tests and Inspections

As part of plant operation, periodic tests, surveillance inspections, and instrument calibrations are made to monitor equipment condition and performance. Most components are in use regularly; therefore, assurance of the availability and performance of the systems and equipment is provided by control room and/or local indication. Further information concerning preoperational and startup testing is described in Chapter 14.0.

Technical Specifications have been established concerning calibration, checking, and sampling of the CVCS.

9.3.4.5 Instrumentation Application

Process control instrumentation is provided to acquire data concerning key parameters about the CVCS. The location of the instrumentation is shown on Figure 9.3-8.

The instrumentation furnishes input signals for monitoring and/or alarming purposes. Indications and/or alarms are provided for the following parameters:

a. Temperature

b. Pressure

c. Flow

d. Water level

The instrumentation also supplies input signals for control purposes. Some specific control functions are:

a. Letdown flow is diverted to the volume control tank upon high temperature indication upstream of the mixed bed demineralizers.

b. Pressure upstream of the letdown heat exchanger is controlled to prevent flashing of the letdown liquid downstream of the letdown throttle valves.

c. Charging flow rate is controlled during charging pump operation.

d. Water level is controlled in the volume control tank.

e. Temperature of the boric acid solution in the batching tank is maintained.

f. Reactor makeup is controlled.

g. Temperature of letdown flow to the boron thermal regeneration system is controlled.

h. Temperature of the chilled water flow to the letdown chiller heat exchanger is controlled.

i. Temperature of letdown flow return from the boron thermal regeneration demineralizers is controlled.

j. Deleted

k. Deleted

l. Deleted

m. Boron injection flow is controlled.

9.3.5 SERVICE GAS SYSTEM

The service gas system (SGS) provides nitrogen, hydrogen, carbon dioxide, oxygen, and laboratory gases to plant systems, as required. Bulk storage of service gases is described in Section 2.2 of the Site Addendum. The compressed air system is described in Section 9.3.1, and the diesel generator starting air system is described in Section 9.5.6.

9.3.5.1 <u>Design Bases</u>

9.3.5.1.1 Safety Design Bases

The nitrogen, hydrogen, carbon dioxide, and oxygen systems serve no safety function, and there are no system safety design bases. Since the service gas storage vessels are maintained at high pressure, they are a potential hazard, and the location and design of the tanks and adjacent structures and/or barriers are consistent with the following safety design bases.

SAFETY DESIGN BASIS ONE - Rupture of a compressed gas storage vessel or piping will not cause unacceptable impairment of a safety-related system, structure, or component from blast forces, missile impacts, or pipe whipping.

SAFETY DESIGN BASIS TWO - Rupture of a compressed gas storage vessel or piping will not cause a deficiency of oxygen for breathing purposes in the control rooms.

SAFETY DESIGN BASIS THREE - Rupture of a hydrogen or oxygen storage vessel or piping will not cause the failure of safety-related components, systems, or structures as a result of delayed ignition or explosion.

9.3.5.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - The SGS transports low pressure nitrogen from the site storage facility for use as a cover gas, purge gas for corrosion prevention, and carrier gas. The SGS also transports high pressure nitrogen to be used as a source of potential energy.

POWER GENERATION DESIGN BASIS TWO - The SGS transports hydrogen from the site storage facility and stores hydrogen, in limited quantities within the power block, for use, in recombination with oxygen, as a cover gas, as a cooling medium, and as a stripping agent.

POWER GENERATION DESIGN BASIS THREE - The SGS transports carbon dioxide from the site storage facility to be used as a purge gas.

POWER GENERATION DESIGN BASIS FOUR - The SGS transports oxygen from the site storage facility to be used in recombination with hydrogen.

9.3.5.2 System Description

9.3.5.2.1 General Description

The SGS, which is shown in Figure 9.3-9, consists of a network of piping conveying nitrogen, hydrogen, carbon dioxide, and oxygen from site storage facilities to the standard power block for various uses. For each gas entering the power block, a master shutoff valve and a pressure regulator are provided. In addition, for hydrogen lines entering the power block, an excess flow check valve is provided by the site A/E. Section 2.2 of the Site Addendum describes the site gas storage facilities.

High and low pressure nitrogen enter the power block through separate headers.

A separate low-volume source of hydrogen is provided to supply the reactor coolant drain tank that is located inside the containment. This source is located outside of the laundry decontamination facility and is outside any safety-related building. If purging of the reactor coolant drain tank becomes necessary, a separate low-volume source of nitrogen may be provided at the same location.

Each of the other gases enters the power block at a single location. Figure 9.3-10 shows where each of the gases enters the power block.

The service gas main headers are all 2-inch lines, with the exception of the high pressure nitrogen supply line which is 1 inch to reduce the potential for failure. From the headers, 1-inch service gas lines are routed to their associated service location.

Table 9.3-11 lists the various components supplied by the SGS.

In addition to the major gas distribution headers, gas bottles are located within the plant to provide small quantities of specialty gases for laboratory analysis or localized testing. Their location, which is shown in Figure 9.3-10, is in accordance with safety codes. A list of laboratory gases is provided in Table 9.3-12.

9.3.5.2.2 Component Description

The gas storage facilities outside the power block are described in Section 2.2 of the Site Addendum.

Piping and valves are designed and fabricated to meet the requirements of the Power Piping Code, ANSI B31.1. Packless valves are used to minimize gaseous leakage. All headers are carbon steel, except the oxygen piping which is constructed of welded stainless steel.

Storage facilities for laboratory gases are provided in the buildings of the power block as indicated in Figure 9.3-10.

9.3.5.2.3 System Operation

During normal operation, service gas received from the site storage facility is maintained at the required pressure through pressure regulators. Service gas flow is controlled by those systems being served.

During plant startup and shutdown, service gas for filling and purging is manually controlled.

9.3.5.3 Safety Evaluation

Safety evaluations are numbered to correspond to the safety design basis.

SAFETY EVALUATION ONE - Section 2.2 of the Site Addendum provides an evaluation which demonstrates that any hazards due to the gas storage facility will not adversely affect safety-related structures, systems, or components due to blast force, missile impact, or pipe whipping.

SAFETY EVALUATION TWO - The routing of service gases within the standard power block will not allow escaping gas to enter the control building air intakes. The effects of a high pressure nitrogen pipe rupture are discussed in Section 3.6. Section 2.2 of the Site

Addendum provides an evaluation of gas storage facilities outside the standard power block.

SAFETY EVALUATION THREE - All lines associated with the distribution of hydrogen within the safety-related structure are less than 1 inch in diameter and carry moderate energy fluid, hence no break needs to be assumed per NRC Branch Technical Position MEB 3-1. In addition, if a rupture were to occur there is insufficient volume associated with the bottle storage for the reactor coolant drain tank to create an explosive mixture. For the hydrogen bulk storage supply, an excess flow check valve is provided to keep the maximum blowdown below an explosive mixture.

The maximum rate of blowdown for hydrogen from a ruptured pipe is eight scfm. The minimum ventilation rate in areas where hydrogen gas lines are routed is 300 scfm, which results in a maximum hydrogen gas concentration of less than 3 volume percent. Thus, an explosive mixture cannot form. Oxygen is not routed within safety-related structures.

9.3.5.4 Tests and Inspections

Preoperational testing is performed, as outlined in Chapter 14.0. The system is inspected to verify that the applicable plans, drawings, and specification are met. Applicable code-required testing is performed. The service gas system operates continuously throughout the life of the plant, thus demonstrating the structural and leaktight integrity of all the components.

9.3.5.5 Instrumentation Application

Pressure indication is provided in most systems served by the service gas system.

9.3.6 BORON RECYCLE SYSTEM

The boron recycle system (BRS) receives reactor coolant effluent for the purpose of recycling it as boric acid and makeup water. The BRS decontaminates the effluent by means of demineralization and gas stripping.

9.3.6.1 Design Bases

9.3.6.1.1 Safety Design Basis

The BRS serves no safety function.

9.3.6.1.2 Power Generation Design Basis

POWER GENERATION DESIGN BASIS ONE - The BRS collects and processes plant effluents which can be readily reused as makeup to the RCS. For the most part, this

effluent is the deaerated, tritiated, borated, and radioactive water from the letdown and process drains.

The BRS is designed to collect the excess reactor coolant that results from certain plant operations, as described in Section 9.3.6.2.1.

POWER GENERATION DESIGN BASIS TWO - The BRS is designed to process the total volume of water collected during a core cycle as well as shortterm surges. The design surge is that produced by a cold shutdown and subsequent startup during the latter part of a core cycle or by a refueling shutdown and startup.

POWER GENERATION DESIGN BASIS THREE - The water collected by the BRS contains dissolved gases, boric acid, and suspended solids. Based on reactor operations with 1 percent of the rated core thermal power being generated by fuel elements with defective cladding, the BRS is designed to provide sufficient cleanup of the water to satisfy the chemistry requirements of the recycled reactor makeup water and the 7000 to 7700 ppm boric acid solution.

POWER GENERATION DESIGN BASIS FOUR - The BRS uses design and fabrication codes consistent with quality group D (augmented), as assigned by Regulatory Guide 1.143 for radioactive waste management systems.

9.3.6.2 System Description

9.3.6.2.1 General Description

The BRS is shown in Figure 9.3-11. The BRS is designed to collect, via the letdown line in the chemical and volume control system (CVCS), the excess reactor coolant that results from the following plant operations during one core cycle:

a. Dilution for core burnup from approximately 1,200 ppm boron at the beginning of an annual core cycle to approximately 10 ppm near the end of the core cycle.

b. Hot shutdowns and startups. Four hot shutdowns are assumed to take place during an annual core cycle.

c. Cold shutdowns and startups. Three cold shutdowns are assumed to take place during an annual core cycle.

d. Refueling shutdown and startup.

The BRS also collects water from the following sources:

a. Reactor coolant drain tank (liquid waste processing system) - collects leakoff type drains from equipment inside the containment.

b. Volume control tank and charging pump suction pressure reliefs (CVCS), safety injection pump pressure reliefs, and RHR pump pressure reliefs.

c. Boric acid blending tee (CVCS) - provides for the storage of boric acid if a boric acid tank must be emptied for maintenance. The boric acid solution is stored in a recycle holdup tank after first being diluted with reactor makeup water by the blending tee, if necessary, to ensure against precipitation of the boric acid in the unheated recycle holdup tank.

d. Accumulators (safety injection system) - collect effluent resulting from leak testing of accumulator check valves.

e. Liquid waste processing system - provides waste water treatment prior to discharge.

f. Fuel transfer canal (via the spent fuel pool cooling and cleanup system) - provides a means of storing the fuel transfer canal water in the event maintenance is required on the transfer equipment.

g. Valve leakoffs and equipment drains.

h. Deleted

i. Boron thermal regeneration system (BTRS) demineralizers - provide a means for recycling the boric acid present in the BTRS demineralizers through flushing.

When water is directed to the BRS, the flow first passes through the recycle evaporator feed demineralizers and filters and then into the recycle holdup tanks. The recycle evaporator feed pumps can be used to transfer liquid from one recycle holdup tank to the other, if desired. When sufficient water is accumulated to warrant processing, the recycle evaporator feed pumps take suction from the selected recycle holdup tank.

All portions of the BRS which contain concentrated boric acid solution are located within a heated area in order to maintain the solution temperature at ≥65°F. This is 10°F above the solubility limit for the nominal 7000 ppm boric acid solution.

9.3.6.2.2 Component Descriptions

Codes and standards applicable to the BRS are listed in Table 3.2-1 and 9.3-13. The BRS is designed and constructed in accordance with quality group D (augmented), as assigned by Regulatory Guide 1.143 for radioactive waste management systems. The BRS is housed within a seismically designed building, as described in Section 3.8.6. The performance parameters to which the individual components of the BRS are designed are listed in Table 9.3-13.

RECYCLE EVAPORATOR FEED PUMPS - Two centrifugal, canned pumps supply feed to the liquid radwaste treatment system from the recycle holdup tanks. The pumps can also be used to recirculate water from the recycle holdup tanks through the recycle evaporator feed demineralizers to the alternate liquid radwaste treatment system for cleanup, if desired. An auxiliary discharge connection is provided to return water to the fuel transfer canal from the recycle holdup tanks, if those tanks were used for storage of fuel transfer canal water during refueling equipment maintenance. Another auxiliary discharge connection is provided to supply water to the suction of the charging pumps (CVCS) for refilling the RCS after loop or system draindown.

RECYCLE HOLDUP TANKS - Two recycle holdup tanks provide storage for radioactive fluid which is discharged from the RCS during startup, shutdown, load changes, and boron dilution. The sizing criteria is based on the design surge that is produced by a cold shutdown and subsequent startup during the latter part of core cycle or by refueling shutdown and startup.

Each tank has a diaphragm which prevents air from dissolving in the water and prevents the hydrogen and fission gases in the water from mixing with the air. The volume in the tank above the diaphragm is continuously ventilated with building supply air, and any gas which accumulates below the diaphragm is intermittently vented to the gaseous waste processing system via the recycle holdup tank vent eductor.

In addition to the collection of effluents, the recycle holdup tanks provide the following functions:

a. Serve as a head tank for the recycle evaporator feed pumps.

b. Provide holdup for a RCS drain to the centerline of the reactor vessel nozzles, including the pressurizer and steam generators.

c. Provide storage for fuel transfer canal water during refueling equipment maintenance.

d. Collect discharges from the various relief valves.

e. Boric acid concentrates storage.

RECYCLE EVAPORATOR FEED DEMINERALIZERS - Two flushable, demineralizers remove fission products from the fluid directed to the recycle holdup tanks. The demineralizers also provide a means of cleaning the recycle holdup tank contents via recirculation.

RECYCLE EVAPORATOR CONDENSATE DEMINERALIZER - A flushable, anion demineralizer is provided as a polishing demineralizer. The demineralizer also provides a means of cleaning up the reactor makeup water storage tank contents. As an option,

this demineralizer may be operated with a mixed bed in order to provide for removal of cations as well as anions.

RECYCLE EVAPORATOR FEED FILTER - This filter collects resin fines and particulates from the fluid entering the recycle holdup tanks.

RECYCLE EVAPORATOR CONDENSATE FILTER - This filter collects resin fines and particulate.

RECYCLE EVAPORATOR CONCENTRATES FILTER - This filter removes particulates.

RECYCLE HOLDUP TANK VENT EDUCTOR - The eductor is designed to pull gases from in a recycle holdup tank and deliver them to the gaseous waste processing systems, when used Nitrogen, provided by the standby waste gas compressor, provides the motive force.

9.3.6.2.3 System Operation

The BRS is manually operated, with the exception of a few automatic protection functions. These automatic functions protect the recycle evaporator feed demineralizers from high inlet temperature and high differential pressure, prevent high vacuum from being drawn on the recycle holdup tank, protect the recycle evaporator feed pumps from low net positive suction head. The BRS has sufficient instrumentation readouts and alarms to provide the operator information to assure proper system operation.

RECYCLE HOLDUP TANK VENTING - Because hydrogen is dissolved in the reactor coolant at a concentration of 25 - 50cc hydrogen per kilogram of reactor coolant, a portion of the hydrogen along with fission gases will come out of solution in the recycle holdup tank. The total integrated flow from the letdown line and the reactor coolant drain tank to the recycle holdup tanks is monitored.

If venting of either recycle holdup tank to the gaseous radwaste system is required, the following steps can be performed:

a. All inlets to the recycle holdup tanks are closed.

b. The recycle holdup tank is emptied of water by liquid processing or transferring it to the other recycle holdup tank.

c. The standby waste gas compressor is lined up to the recycle holdup tank vent eductor. Normally, the standby compressor will feed the other waste gas compressor which is lined up to a catalytic recombiner and a high activity gas decay tank. However, after an RCS loop drain or spent fuel pool drain, a shutdown gas decay tank is used instead of a high activity gas decay tank. This precludes the accumulation of air (i.e., nitrogen) in the high activity gas decay tanks.

d. The standby gas compressor is started up, and the vent from the holdup tank is opened. The vent flow is throttled to approximately 1 scfm. At this time, a sample of the vent gases can be taken to check the composition.

e. When the gases have been vented from the recycle holdup tank, the pressure in the vent line decreases, which automatically trips the recycle holdup tank vent isolation valve closed.

f. After the vent isolation closes, the manual vent valve is closed, the gas compressor is shut down, and the recycle holdup tank inlets and outlets are lined up for normal use.

MAINTENANCE DRAINS - When large amounts of water must be drained from the RCS or the fuel storage area (or fuel transfer canal) to the BRS, a recycle holdup tank is drained and vented. The water can then be stored in this tank until maintenance is completed and, after checking the chemistry, returned.

REACTOR MAKEUP WATER CLEANUP - If the reactor makeup water tank contents require purification, it can be recirculated through the recycle evaporator condensate demineralizer until its chemistry is within specifications. If further processing is necessary, water from the reactor makeup water storage tank can be directed through the recycle evaporator condensate demineralizer and into the recycle holdup tanks for further treatment.

9.3.6.3 Safety Evaluation

The BRS has no safety-related functions.

9.3.6.4 Tests and Inspections

The BRS is in intermittent use throughout normal reactor operation. Periodic visual inspection and preventive maintenance are conducted using normal industry practice. Refer to Chapter 14.0 for further information concerning preoperational and startup testing.

9.3.6.5 Instrumentation Application

The instrumentation available for the BRS is discussed below. Alarms are provided as noted. Instrumentation is provided to ensure proper operation and to permit the operator to monitor all normal operation, to diagnose malfunctions, and to rectify operating procedures.

TEMPERATURE - Instrumentation is provided to measure the temperature of the inlet flow to the recycle evaporator feed demineralizers and to control a three-way bypass valve. If the inlet temperature becomes too high, the instrumentation aligns the valve to

bypass the demineralizers. Local temperature indication and a high temperature alarm on the BRS panel are provided by this instrumentation.

PRESSURE - Instrumentation is provided to measure the pressure differential across the recycle evaporator feed demineralizers and to control the same three-way valve as discussed above (but independently of the temperature control). If the pressure drop through the demineralizers is too high, this instrumentation aligns the valve to divert flow directly to the recycle evaporator feed filter. Local pressure differential indication and a high alarm on the BRS panel are provided by this instrumentation.

Instrumentation is provided to measure the pressure differential across the recycle evaporator feed filter, the recycle evaporator concentrates filter, and the recycle evaporator condensate filter. Local indication of the differential pressure is provided.

TABLE 9.3-1 COMPONENT DESCRIPTION COMPRESSED AIR SYSTEM

Component	
Air Compressors	
Type	Rotary Screw, non-lubricated
Capacity, scfm, each	845
Quantity	3
Motor horsepower	250
Operating pressure, psig	128
Design pressure, psig	150
Air Receivers	
Type	Vertical
Quantity	3
Capacity, ft^3, each	57
Operating pressure, psig	128
Design pressure, psig	150
Supply gas pressure, psig	128
Stored energy, ft-lb, each	3.98×10^6
Design code	ASME, Section VIII
Prefilters and Afterfilters	
Type	Cartridge, disposable
Quantity	2
Capacity, scfm, each	1000
Operating pressure, psig	128
Design pressure, psig	150
Design code	ASME, Section VIII
Air Dryers	
Type	Heatless, desiccant
Quantity	2
Capacity, scfm, each	1000
Operating pressure, psig	128
Design pressure, psig	150
Design code	ASME, Section VIII
Aux. Feedwater Control Valve and Main Steam Atmospheric Relief Valve Accumulator	
Type	Horizontal, carbon steel
Quantity	4
Capacity, ft^3, each	25
Design pressure, psig	850

TABLE 9.3-1 (Sheet 2)

Component	
Supply pressure, psig	750
Stored energy, ft-lb, each	9.63×10^6
Code requirements	ASME III, Class 3
Valve operating time provided, hrs/valve	8 (One valve cycle every 20 min./aux. F.W. control valve) (One valve cycle every 10 min./M.S. atm. relief valve)
Main Feedwater Control Valve Accumulator	
Type	Vertical, carbon steel
Quantity	1
Capacity, ft^3, each	30
Design pressure, psig	825
Supply pressure, psig	750
Stored energy, ft-lb, each	1.55×10^7
Code requirements	ASME III, Class 3
Design Requirements	
Minimum Pressure, psig	400 (to simultaneously close all four main feedwater control valves)

TABLE 9.3-2 SAFETY-RELATED PNEUMATICALLY OPERATED VALVES

Valve Number	Description	Safe Position	Failure Mode on Loss of Air Supply	Safety Function	Notes
AB-HV-05	Loop 2 Steam Supply to AFW Pump Turbine	Open	Open	Admit steam to AFW pump turbine and secondary side pressure boundary isolation	
AB-HV-06	Loop 3 Steam Supply to AFW Pump Turbine	Open	Open	↓	
AB-HV-12	Main Steam Iso. Bypass Valve Loop 4	Closed	Closed	Secondary side pressure boundary isolation and steam line warmup	
AB-HV-15	Main Steam Iso. Bypass Valve Loop 1	Closed	Closed		
AB-HV-18	Main Steam Iso. Bypass Valve Loop 2	Closed	Closed		
AB-HV-21	Main Steam Iso. Bypass Valve Loop 3	Closed	Closed	↓	
AB-HV-48	Loop 2 Steam Supply to AFW Turbine Bypass	Closed	Closed	Secondary side pressure boundary isolation and steam line keep warm	
AB-HV-49	Loop 3 Steam Supply to AFW Turbine Bypass	Closed	Closed	↓	
AB-LV-07	Main Steam Line Drain Valve Loop 3	Closed	Closed	Secondary side pressure boundary isolation and condensate drain	
AB-LV-08	Main Steam Line Drain Valve Loop 2	Closed	Closed		
AB-LV-09	Main Steam Line Drain Valve Loop 1	Closed	Closed		
AB-LV-10	Main Steam Line Drain Valve Loop 4	Closed	Closed	↓	
AB-PV-01	Steam Gen. A Atm. Relief Valve	Closed	Closed	Secondary side pressure boundary isolation, secondary side heat removal, and pressure relief	2
AB-PV-02	Steam Gen. B Atm. Relief Valve	Closed	Closed		2
AB-PV-03	Steam Gen. C Atm. Relief Valve	Closed	Closed		2
AB-PV-04	Steam Gen. D Atm. Relief Valve	Closed	Closed	↓	2
AE-FV-43	Steam Gen. A Chemical Control	Closed	Closed	Secondary side pressure boundary isolation and chemistry control	
AE-FV-44	Steam Gen. B Chemical Control	Closed	Closed		
AE-FV-45	Steam Gen. C Chemical Control	Closed	Closed		
AE-FV-46	Steam Gen. D Chemical Control	Closed	Closed	↓	
AE-FCV-510	Feedwater Control Valve Loop 1	Closed	Closed	Backup valve for secondary side pressure boundary isolation	
AE-FCV-520	Feedwater Control Valve Loop 2	Closed	Closed		
AE-FCV-530	Feedwater Control Valve Loop 3	Closed	Closed		
AE-FCV-540	Feedwater Control Valve Loop 4	Closed	Closed	↓	
AE-FCV-550	Feedwater Control Bypass Valve Loop 1	Closed	Closed	Backup valve for secondary side pressure boundary isolation	
AE-FCV-560	Feedwater Control Bypass Valve Loop 2	Closed	Closed		
AE-FCV-570	Feedwater Control Bypass Valve Loop 3	Closed	Closed		
AE-FCV-580	Feedwater Control Bypass Valve Loop 4	Closed	Closed	↓	

TABLE 9.3-2 (Sheet 2)

Valve Number	Description	Safe Position	Failure Mode on Loss of Air Supply	Safety Function	Notes
AL-HV-06	Turb. AFP Disch. to Steam Gen. D	Open/Close	Open	Control AFW flow to steam generators;	1
AL-HV-08	Turb. AFP Disch. to Steam Gen. A	Open/Close	Open	isolation of AFW to broken loop	1
AL-HV-10	Turb. AFP Disch. to Steam Gen. B	Open/Close	Open	↓	1
AL-HV-12	Turb. AFP Disch. to Steam Gen. C	Open/Close	Open	↓	1
BB-HV-8026	Ctmt. Iso. Valve - Nitrogen to PRT	Closed	Closed	Containment isolation	
BB-HV-8027	Ctmt. Iso. Valve - Nitrogen to PRT	Closed	Closed	Containment isolation	
BG-HV-8152	Ctmt. Iso. Valve - Letdown Line	Closed	Closed	Containment isolation	
BG-HV-8160	Ctmt. Iso. Valve - Letdown Line	Closed	Closed	Containment isolation	
BL-HV-8047	Ctmt. Iso. Valve - Reactor Makeup Water	Closed	Closed	Containment isolation	
BM-HV-01	Steam Gen. A to SGBD Flash Tank Valve	Closed	Closed	Secondary side pressure boundary isolation	
BM-HV-02	Steam Gen. B to SGBD Flash Tank Valve	Closed	Closed	↓	
BM-HV-03	Steam Gen. C to SGBD Flash Tank Valve	Closed	Closed	↓	
BM-HV-04	Steam Gen. D to SGBD Flash Tank Valve	Closed	Closed	↓	
BN-HCV-8800A	RWST Iso. Valve to SFP Cleanup	Closed	Closed	System pressure boundary isolation	
BN-HCV-8800B	RWST Iso. Valve to SFP Cleanup	Closed	Closed	System pressure boundary isolation	
EF-HV-43	ESW to Air Compressor Iso. Valve	Closed	Closed	System pressure boundary isolation	
EF-HV-44	ESW to Air Compressor Iso. Valve	Closed	Closed	System pressure boundary isolation	
EG-HV-69A	CCW Supply Waste Header Iso. Valve	Closed	Closed	System pressure boundary isolation	
EG-HV-69B	CCW Return Waste Header Iso. Valve	Closed	Closed	↓	
EG-HV-70A	CCW Supply Waste Header Iso. Valve	Closed	Closed	↓	
EG-HV-70B	CCW Return Waste Header Iso. Valve	Closed	Closed	↓	
EG-TV-29	CCW Heat Exchanger A Bypass Iso. Valve	Closed	Closed	Maintain CCW heat exchanger discharge temperature and isolate bypass flow	
EG-TV-30	CCW Heat Exchanger B Bypass Iso. Valve	Closed	Closed	↓	
EJ-FCV-0618	RHR HX A Bypass	Closed	Closed	Isolate bypass flow	
EJ-FCV-0619	RHR HX B Bypass	Closed	Closed	Isolate bypass flow	
EJ-HCV-0606	RHR HX A Discharge	Open	Open	Remain open to ensure flow path	
EJ-HCV-0607	RHR HX B Discharge	Open	Open	Remain open to ensure flow path	
EJ-HCV-8825	Test Line Iso. Valve - Hot Leg Injection	Closed	Closed	Containment isolation	
EJ-HCV-8890A	Test Line Iso. Valve - Cold Leg Injection	Closed	Closed	Containment isolation	
EJ-HCV-8890B	Test Line Iso. Valve - Cold Leg Injection	Closed	Closed	Containment isolation	

TABLE 9.3-2 (Sheet 3)

Valve Number	Description	Safe Position	Failure Mode on Loss of Air Supply	Safety Function	Notes
EM-HV-8823	Test Line Iso. Valve - SI to RCS Cold Legs	Closed	Closed	Containment isolation	
EM-HV-8824	Test Line Iso. Valve - Hot Legs 1 and 4	Closed	Closed	Containment isolation	
EM-HV-8843	Test Line Iso. Valve - Boron Inj. Line	Closed	Closed	Containment isolation	
EM-HV-8871	Ctmt. Iso. Valve - SI Test Line	Closed	Closed	Containment isolation	
EM-HV-8881	Test Line Iso. Valve - Hit Legs 2 and 3	Closed	Closed	Containment isolation	
EM-HV-8882	Boron Inj. Test Line Iso. Valve	Closed	Closed	System pressure boundary isolation	
EM-HV-8888	Ctmt. Iso. Valve - Accumulator Fill Line	Closed	Closed	Containment isolation	
EM-HV-8889A	HL 1 SI Test Line	Closed	Closed	System pressure boundary isolation	
EM-HV-8889B	HL 2 SI Test Line	Closed	Closed	System pressure boundary isolation	
EM-HV-8889C	HL 3 SI Test Line	Closed	Closed	System pressure boundary isolation	
EM-HV-8889D	HL 4 SI Test Line	Closed	Closed	System pressure boundary isolation	
EM-HV-8964	Ctmt. Iso. Valve - SI Test Line	Closed	Closed	Containment isolation	
EF-HV-8875A	N_2 Supply Iso. Valve	Closed	Closed	System pressure boundary isolation	
EP-HV-8875B	N_2 Supply Iso. Valve	Closed	Closed	System pressure boundary isolation	
EP-HV-8875C	N_2 Supply Iso. Valve	Closed	Closed	System pressure boundary isolation	
EP-HV-8875D	N_2 Supply Iso. Valve	Closed	Closed	System pressure boundary isolation	
EP-HV-8877A	Acc. Tank A to SIS Test Line Iso. Valve	Closed	Closed	System pressure boundary isolation	
EP-HV-8877B	Acc. Tank B to SIS Test Line Iso. Valve	Closed	Closed	System pressure boundary isolation	
EP-HV-8877C	Acc. Tank C to SIS Test Line Iso. Valve	Closed	Closed	System pressure boundary isolation	
EP-HV-8877D	Acc. Tank D to SIS Test Line Iso. Valve	Closed	Closed	System pressure boundary isolation	
EP-HV-8878A	Acc. Tank Fill from SI Pump	Closed	Closed	System pressure boundary isolation	
EP-HV-8878B	Acc. Tank Fill from SI Pump	Closed	Closed	System pressure boundary isolation	
EP-HV-8878C	Acc. Tank Fill from SI Pump	Closed	Closed	System pressure boundary isolation	
EP-HV-8878D	Acc. Tank Fill from SI Pump	Closed	Closed	System pressure boundary isolation	
EP-HV-8879A	Acc. Tank A to SIS Test Line Iso. Valve	Closed	Closed	System pressure boundary isolation	
EP-HV-8879B	Acc. Tank B to SIS Test Line Iso. Valve	Closed	Closed	System pressure boundary isolation	
EP-HV-8879C	Acc. Tank C to SIS Test Line Iso. Valve	Closed	Closed	System pressure boundary isolation	
EP-HV-8879D	Acc. Tank D to SIS Test Line Iso. Valve	Closed	Closed	System pressure boundary isolation	
EP-HV-8880	Ctmt. Iso. Valve - N_2 Supply to Accum.	Closed	Closed	Containment isolation	
FC-FV-310	AFP Steam Trap Isolation Valve	Closed	Closed	Condensate removal	
GT-HZ-04	Ctmt. Iso. Valve - Ctmt. Mini Purge	Closed	Closed	Containment isolation	

TABLE 9.3-2 (Sheet 4)

Valve Number	Description	Safe Position	Failure Mode on Loss of Air Supply	Safety Function	Notes
GT-HZ-05	Ctmt. Iso. Valve - Ctmt. Mini Purge	Closed	Closed	Containment isolation	
GT-HZ-06	Ctmt. Iso. Valve - Ctmt. Large Vol.	Closed	Closed	Containment isolation	
GT-HZ-07	Ctmt. Iso. Valve - Ctmt. Large Vol.	Closed	Closed	Containment isolation	
GT-HZ-08	Ctmt. Iso. Valve - Ctmt. Large Vol.	Closed	Closed	Containment isolation	
GT-HZ-09	Ctmt. Iso. Valve - Ctmt. Large Vol.	Closed	Closed	Containment isolation	
GT-HZ-11	Ctmt. Iso. Valve - Ctmt. Mini Purge	Closed	Closed	Containment isolation	
GT-HZ-12	Ctmt. Iso. Valve - Ctmt. Mini Purge	Closed	Closed	Containment isolation	
HB-HV-7126	Ctmt. Iso. Valve - RCDT to Waste Gas Comp.	Closed	Closed	Containment isolation	
HB-HV-7136	Ctmt. Iso. Valve - RCDT to Recy. Holdup Tank	Closed	Closed	Containment isolation	
HB-HV-7150	Ctmt. Iso. Valve - RCDT to Recy. Holdup Tank	Closed	Closed	Containment isolation	
HB-HV-7176	Ctmt. Iso. Valve - RCDT to Waste Gas Comp.	Closed	Closed	Containment isolation	
KA-FV-29	Ctmt. Iso. Valve - Inst. Air Line	Closed	Closed	Containment isolation	
LF-FV-96	Ctmt. Iso. Valve - Sump to Floor Drain Tank	Closed	Closed	Containment isolation	

NOTES: (1) Provided with backup compressed gas supply to open for safety functions

(2) Provided with backup compressed gas supply to modulate valve as required during cooldown from hot shutdown condition to cold shutdown

TABLE 9.3-3 PRIMARY SAMPLING SYSTEM SAMPLE POINT DESIGN DATA

		Sample Conditions (Operating)			
Sample Point No.	Sample Name primary Sampling System	Pressure psig	Temp F	Typical Sampling Frequency	Typical Analysis
1	Steam generator blowdown A	1091	557	Continuous*	Gross γ activity by liquid monitor
2	Steam generator blowdown B	1091	557	Continuous*	Gross γ activity by liquid monitor
3	Steam generator blowdown C	1091	557	Continuous*	Gross γ activity by liquid monitor
4	Steam generator blowdown D	1091	557	Continuous*	Gross γ activity by liquid monitor
5	RCS hot legs sample (loop 1 or 3)	2235	618	3/week 1/week	Gross β-γ tritium, hydrogen, oxygen, lithium, radio iodine, pH, conductivity, chloride/fluoride, SiO_2, Al, Ca, Mg
6	Pressurizer liquid space	2235	653	1/week	Chloride/fluoride, oxygen, boron, lithium, pH, conducitivity, hydrogen
7	Pressurizer vapor space	2235	653	As required	Hydrogen, oxygen, nitrogen, fission gases
8	CVCS letdown upstream of demineralizer	300	115	Continuous**	Gross gamma, activity by SJRE0001 Note: Other data same as RCS
9	CVCS letdown downstream of demineralizer	300	115	1/week	Chloride, fluoride
10	Reactor makeup water storage tank	100	80	3/week 1/week	Chloride/fluoride, total solid, oxygen, pH, conductivity Sodium, tritium,SiO_2, Al, Ca, Mg
11	Accumulator tanks A, B, C, and D	650	150	1/month	Boric acid, chloride/fluoride
12	Boric acid tank A and B	Atmospheric	120	1/week 1/month	Boric acid Chloride/fluoride
13	Reactor coolant drain tank	134	140	As required	Gross β-γ, pH
14	***Residual heat removal heat exchanger A and B	540	140	3/week 1/week	Boron, chloride/fluoride, lithium, gross β-γ Mg, pH,SiO_2, Al, Ca
15	Boron thermal regeneration demineralizer effluent	180	115	As required	Boric acid, pH, gross β-γ, chloride/fluoride

* When steam generator blowdown in in service

** When normal letdown is in service CDP-ZZ-00200, Chemistry Schedule and Water Specifications, establishes system chemistry criteria, analyses performed and the sampling schedule.

*** When RHR is in service

TABLE 9.3-4 RADWASTE SAMPLING SYSTEM SAMPLE POINT DESIGN DATA

Sample Point No.	Sample Name Radwaste Sampling System	Sample Conditions (Operating) Pressure psig	Temp F	Typical Sampling Frequency	Typical Analysis
1	Waste holdup tank	108	100	Each batch	Isotopic -, general surveillance
2	Waste evaporator condensate tank	108	120	Each batch	Isotopic -, general surveillance
3	Deleted				
4	Chemical drain tank	108	100	As required	General surveillance
5	Laundry and hot shower tank A	108	100	As required	Isotopic -, general surveillance
6	Laundry and hot shower tank B	108	100	As required	Isotopic -, general surveillance
7	Floor drain tanks A and B	108	100	Each batch	Isotopic -, general surveillance
8	Waste monitor tank A	108	100	Each batch	Isotopic -, general surveillance
9	Waste monitor tank B	108	100	Each batch	Isotopic -, general surveillance
10	Steam generator blowdown surge tank	200	150	As required	Isotopic -, pH, suspended solids
11	Recycle holdup tanks A and B	110	115	Each batch	Isotopic -, boron, general surveillance
12	Recycle evaporator condensate demineralizer	65	210	As required	Isotopic -, pH, boron, tritium, general surveillance
13	Fuel pool cleanup demineralizer inlet	134	140	1/week	Isotopic -, chloride, fluoride, boron, pH, Ca, Mg
14	Fuel pool cleanup demineralizer outlet	134	140	1/week	Isotopic -, chloride, fluoride

TABLE 9.3-5 PROCESS SAMPLING SYSTEM SAMPLE POINT DESIGN DATA

Secondary sample points and sampling frequencies are controlled under the Chemistry Program and are specified within applicable Chemistry Department Procedures.

TABLE 9.3-6 LIST OF GRAB SAMPLE POINTS FOR PRIMARY AND RADWASTE SAMPLING SYSTEMS

Sample Point No	Sample Name	Type of Sample	Typical Sampling Frequency
1	Pressurizer relief tank, vapor space	Noble gas	Monthly
2	Volume control tank, vapor space	Noble gas	Weekly
3	Volume control tank	Liquid	Weekly
4	CVCS letdown chiller heat exchanger (chill water)	Liquid	As required
5	Boric acid batch tank	Liquid	Each batch
6	Reactor makeup water storage tank	Liquid	Monthly
7	Steam generator blow down demineralizer inlet and outlet	Liquid	As required
8	Refueling water storage tank	Liquid	Weekly
9	Fuel pool cooling heat exchangers A and B	Liquid	Monthly
10	Component cooling water heat exchanger	Liquid	Every 2 weeks
11	Residual heat removal pumps A and B	Liquid	3/week
12	Refueling water storage tank return from RHR system	Liquid	As required
13	Safety injection pump test return to refueling water storage tank	Liquid	As required
14	Deleted		
15	Deleted		
16	Deleted		
17	Deleted		
18	Gas decay tanks A, B, C, D, E, F, and G	Noble gas	Prior to discharge
19	Deleted		
20	Liquid waste charcoal absorber	Liquid	As required
21	Waste monitor tank demineralizer inlet and outlet	Liquid	As required
22	Waste evaporator condensate demineralizer	Liquid	As required
23	Reactor coolant drain tank vapor space	Noble gas	As required

TABLE 9.3-6 (Sheet 2)

Sample Point No	Sample Name	Type of Sample	Typical Sampling Frequency
24	Deleted		
25	Deleted		
26	Deleted		
27	Spent resin sluice filter (primary)	Liquid	As required
28	Spent resin sluice filter (secondary)	Liquid	As required
29	Recycle evaporator feed demin A and B	Liquid	Monthly
30	Recycle holdup tank vapor space A and B	Noble gas	As required
31	Deleted		
32	Sec. liquid waste drain collection tank	Liquid	Each batch
33	Sec. liquid waste charcoal absorber	Liquid	As required
34	Sec. liquid waste demineralizer	Liquid	As required
35	High TDS collector tank	Liquid	Each batch
36	Low TDS collector tank	Liquid	Each batch
37	Deleted		
38	Reactor containment normal sump	Liquid	As required
39	Laundry and hot shower charcoal absorber	Liquid	As required
40	Deleted		

TABLE 9.3-7 FLOOR AND EQUIPMENT DRAINAGE SYSTEM SINGLE ACTIVE FAILURE ANALYSIS

Component	Failure Position	Separation Group	Comments and Analysis
FV95	As is	1	One of two containment isolation valves. If valve fails, the other valve in separation group 4 will operate.
FV96	Closed	4	One of two containment isolation valves. If valve fails, the other valve in separation group 1 will operate.
HV105	As is	4	One of two motor-operated auxiliary building sump pump discharge isolation valves. If valve fails, the other valve in separation group 1 will operate.
HV106	As is	1	One of two motor-operated auxiliary building sump pump discharge isolation valves. If valve fails, the other valve in separation group 4 will operate.
LE102, LIT102	Anywhere in range	1	One level transmitter is provided for each RHR pump room with power supplied by the same separation group as the safety-related equipment in the associated room. If one fails, the indication system for the other pump room train will operate.
LE101, LIT101	Anywhere in range	4	One level transmitter is provided for each RHR pump room with power supplied by the same separation group as the safety-related equipment in the associated room. If one fails, the indication system for the other pump room train will operate.
LE103, LIT103	Anywhere in range	1	One of two auxiliary building sump level transmitter and indication systems. If one fails, the other train will operate.
LE104, LIT104	Anywhere in range	4	One of two auxiliary building sump level transmitter and indication systems. If one fails, the other train will operate.

TABLE 9.3-7 (Sheet 2)

Component	Failure Position	Separation Group	Comments and Analysis
LE105, LIT105	Anywhere in range	1	One level transmitter is provided for each diesel generator building sump with power supplied by the same separation group as the safety-related equipment in the associated room. If one fails, the other train will be protected by the other indication system.
LE106, LIT106	Anywhere in range	4	One level transmitter is provided for each diesel generator building sump with power supplied by the same separation group as the safety-related equipment in the associated room. If one fails, the other train will be protected by the other indication system.
LE124, LIT124	Anywhere in range	1	One of two control building basement level transmitter and indication systems. If one fails, the other train will operate.
LE125, LIT125	Anywhere in range	4	One of two control building basement level transmitter and indication systems. If one fails, the other train will operate.
LE09, LIT09	Anywhere in range	1	One of two containment normal sump level transmitter and indication systems. If one fails, the other train will operate.
LE10, LIT10	Anywhere in range	4	One of two containment normal sump level transmitter and indication systems. If one fails, the other train will operate.

TABLE 9.3-8 CHEMICAL AND VOLUME CONTROL SYSTEM DESIGN PARAMETERS

General	
Seal water supply flow rate, for four reactor coolant pumps, nominal, gpm	32
Seal water return flow rate, for four reactor coolant pumps, nominal, gpm	12
Letdown flow	
Normal, gpm	75
Maximum, gpm	120
Charging flow (excludes seal water)	
Normal, gpm	55
Maximum, gpm	100
Temperature of letdown reactor coolant entering system, F	<560
Temperature of charging flow directed to reactor coolant system, F	518
Temperature of effluent directed to boron recycle system, F	115
ECCS centrifugal charging pump miniflow, each, gpm	60
Amount of 7000 to 7700 ppm acid solution required to meet cold shutdown requirements shortly after full power operation, gal	18,500
Maximum pressurization required for hydrostatic testing of reactor coolant system, psig	3107
Normal charging pump miniflow, gpm	45

TABLE 9.3-9 CHEMICAL AND VOLUME CONTROL SYSTEM PRINCIPAL COMPONENT DATA SUMMARY

Normal Charging Pump	
Number	1
Design pressure, psig	2,900
Design temperature, F	300
Design flow, gpm	130
Design head, ft	5,900
Material	Austenitic stainless steel
Design code	ASME III - Class 2
Driver	
Type	Electric motor
RPM	3,580
Speed ratio	1:1 (Direct Drive)
Power supply	600 hp, 4160V, 3ϕ Non-Class 1E
Seismic design	
Motor	Non-Category I
Pump	Category I (pressure boundary)
ECCS Centrifugal Charging Pumps	
Number	2
Design pressure, psig	2,800
Design temperature, F	300
Design flow, gpm	150
Design head, ft	5,800
Material	Austenitic stainless steel
Cooling water, gpm	55
Design code	ASME III, Class 2
Driver	
Type	Electric motor
RPM	1,800
Power supply	600 hp, 4,000V, 3ϕ Class 1E
Seismic design	Category I
Boric Acid Transfer Pump	
Number	2
Design pressure, psig	150
Design temperature, F	250
Design flow, gpm	75

TABLE 9.3-9 (Sheet 2)

Design head, ft		235
Material		Austenitic stainless steel
Design code		ASME III, Class 3
Driver		
Type		Electric motor
RPM		3,450
Power supply		20.8hp, 460V, 3ϕ
Seismic design		
Motor		Diesel backed/
Pump		Non-Class 1E Category I
Boron Injection Makeup Pump		
Number		1
Design pressure, psig		150
Design temperature, F		250
Design flow, gpm		80
Design head, ft		250
Material		Austenitic stainless steel
Design code		MS
Seismic design		Non-Category I
Chiller Pumps		
Number		2
Design pressure, psig		150
Design temperature, F		200
Design flow, gpm		400
Design head, ft		150
Material		Carbon steel
Design code		MS
Seismic design		Non-Category I
Regenerative Heat Exchanger		
Number		1
Heat transfer rate at design conditions, Btu/hr		11.0×10^6
	<u>Shell Side</u>	<u>Tube Side</u>
Design pressure, psig	2,485	3,100
Design temperature, F	650	650
Fluid	Borated reactor coolant	Borated reactor coolant
Material	Austenitic stainless steel	Austenitic stainless steel
Design code	ASME III, Class 2	ASME III, Class 2

TABLE 9.3-9 (Sheet 3)

Seismic design	Category I	Category I
Flow, lb/hr	37,300	27,300
Inlet temperature, F	560	130
Outlet temperature, F	290	518
Letdown Heat Exchanger		
Number		1
Heat transfer rate at design conditions, Btu/hr		16.1×10^6
	<u>Shell Side</u>	<u>Tube Side</u>
Design pressure, psig	150	600
Design temperature, F	250	400
Design flow, lbm/hr	498,000	59,600
Fluid	Component cooling water	Borated reactor coolant
Material	Carbon steel	Austenitic stainless steel
Design code	ASME III, Class 3	ASME III, Class 2
Seismic design	Category I	Category I
Excess Letdown Heat Exchanger		
Number		1
Heat transfer rate at design conditions, Btu/hr		5.2×10^6
	<u>Shell Side</u>	<u>Tube Side</u>
Design pressure, psig	150	2,485
Design temperature, F	250	650
Design flow, lb/hr	129,000	12,410
Inlet temperature, F	105	560
Outlet temperature, F	145	165
Fluid	Component cooling water	Borated reactor coolant
Material	Carbon steel	Austenitic stainless steel
Design code	ASME III, Class 3	ASME III,Class 2
Seismic design	Category I	Category I
Seal Water Heat Exchanger		
Number		1
Heat transfer rate at design conditions, Btu/hr		2.0×10^6
	<u>Shell Side</u>	<u>Tube Side</u>
Design pressure, psig	150	220
Design temperature, F	250	250
Design flow, lb/hr	186,000	51,900
Inlet temperature, F	105	156
Outlet temperature, F	121	115

TABLE 9.3-9 (Sheet 4)

Fluid	Component cooling water	Borated reactor coolant
Material	Carbon steel	Austenitic stainless steel
Design code	ASME III, Class 3	ASME III, Class 2
Seismic design	Category I	Category I
Moderating Heat Exchanger		
Number		1
Heat transfer rate at design conditions, Btu/hr		2.53×10^6
Design pressure, psig	300	300
	Shell Side	Tube Side
Design temperature, F	200	200
Design flow, lb/hr	59,600	59,600
Design inlet temperature, boron storage mode, F	50	115
Design outlet temperature, boron storage mode, F	92.4	72.6
Inlet temperature, boron release mode, F	140	115
Outlet temperature, boron release mode, F	123.2	131.8
Material	Austenitic stainless steel	Austenitic stainless steel
Design code [(1)]	ASME VIII	ASME VIII
Seismic design	Non-Category I	Non-Category I
Letdown Chiller Heat Exchanger		
Number		1
Heat transfer rate at design conditions, boron storage mode, Btu/hr		1.65×10^6
	Shell Side	Tube Side
Design pressure, psig	150	300
Design temperature, F	200	200
Design flow, boron storage mode, lb/hr	175,000	59,600
Design inlet temperature, boron storage mode, F	39	72.6
Design outlet temperature, boron storage mode, F	48.4	45
	Shell Side	Tube Side
Flow, boron release mode, lb/hr	175,000	59,600 lb/hr

TABLE 9.3-9 (Sheet 5)

Inlet temperature, boron release mode, F	90	123.7
Outlet temperature, boron release mode, F	99.8	94.9
Material	Carbon steel	Austenitic stainless steel
Design code (1)	ASME VIII	ASME VIII
Seismic design	Non-Category I	Non-Category I
Letdown Reheat Heat Exchanger		
Number		1
Heat transfer rate at design conditions, Btu/hr		1.49×10^6
	<u>Shell Side</u>	<u>Tube Side</u>
Design pressure, psig	300	600
Design temperature, F	200	400
Design flow, lb/hr	59,600	44,700
Inlet temperature, F	115	280
Outlet temperature, F	140	246.7
Material	Austenitic stainless steel	Austenitic stainless steel
Design code (1)	ASME VIII	ASME III, Class 2
Seismic design	Non-Category I	Non-Category I
Volume Control Tank		
Number		1
Volume, ft^3		400
Design pressure, psig		75
Design temperature, F		250
Material		Austenitic stainless steel
Design code		ASME III, Class 2
Seismic design		Category I
Boric Acid Tanks		
Number		2
Capacity, usable, gal		24,000
Design pressure, psig		10
Design temperature, F		200
Material		Austenitic stainless steel
Design code		ASME III, Class 3
Seismic design		Category I
Batching Tank		
Number		1

TABLE 9.3-9 (Sheet 6)

Capacity, gal	800
Design pressure vessel steam jacket, psig	Atmospheric
Design temperature, F	150
(steam jacket)	400
Material	Austenitic stainless steel
Design code	ASME VIII
Seismic design	Non-Category I
Chemical Mixing Tank	
Number	1
Capacity, gal	5
Design pressure, psig	150
Design temperature, F	200
Material	Austenitic stainless steel
Design code	ASME VIII
Seismic design	Non-Category I
Chiller Surge Tank	
Number	1
Volume, gal	500
Design pressure	Atmospheric
Design temperature, F	200
Material	Carbon steel
Design code	ASME VIII
Seismic design	Non-Category I
Mixed Bed Demineralizers	
Number	2
Design pressure, psig	300
Design temperature, F	250
Design flow, gpm	120
Resin volume, each, ft^3	39
Material	Austenitic stainless steel
Design code [(1)]	ASME VIII
Seismic design	Non-Category I
Cation Bed Demineralizers	
Number	1
Design pressure, psig	300
Design temperature, F	250
Design flow, gpm	120

TABLE 9.3-9 (Sheet 7)

Resin volume, ft^3	39
Material	Austenitic stainless steel
Design code (1)	ASME VIII
Seismic design	Non-Category I
Thermal Regeneration Demineralizers	
Number	5
Design pressure, psig	300
Design temperature, F	250
Design flow, gpm	250
Resin volume, ft^3	74.3
Material	Austenitic stainless steel
Design code (1)	ASME VIII
Seismic design	Non-Category I
Reactor Coolant Filter	
Number	1
Design pressure, psig	300
Design temperature, F	250
Design flow, gpm	250
Particle retention	98% of 30 micron size (2)
Material, vessel	Austenitic stainless steel
Design code	ASME III, Class 2
Seismic design	Category I
Seal Water Injection Filters	
Number	2
Design pressure, psig	3,100
Design temperature, F	250
Design flow, gpm	80
Particle retention	98% of 3 micron size (2)
Material, vessel	Austenitic stainless steel
Design code	ASME III, Class 2
Seismic design	Category I
Seal Water Return Filter	
Number	1
Design pressure, psig	300
Design temperature, F	250
Design flow, gpm	250
Particle retention	98% of 30 micron size (2)

TABLE 9.3-9 (Sheet 8)

Material, vessel		Austenitic stainless steel
Design code		ASME III, Class 2
Seismic design		Category I
Boric Acid Filter		
Number		1
Design pressure, psig		300
Design temperature, F		250
Design flow, gpm		250
Particle retention		98% of 30 micron size (2)
Material, vessel		Austenitic stainless steel
Design code		ASME III, Class 3
Seismic design		Category I
Letdown Throttle Valve	<u>45 gpm</u>	<u>75 gpm</u>
Number	1	2
Design flow, lb/hr	22,200	37,300
Differential pressure at design flow, psig	1,885	1,885
Design pressure, psig	2,485	2,485
Design temperature, F	650	650
Material	Austenitic stainless steel	Austenitic stainless steel
Design code	ASME III, Class 2	ASME III, Class 2
Seismic design	Category I	Category I
Chiller Unit		
Number		1
Capacity, Btu/hr		1.66×10^6
(ice tons)		138
Design code		MS
Seismic design		Non-Category I

Note 1 - Table indicates the required code based on its safety-related importance as dictated by service and functional requirements and by the consequences of their failure. Note that the actual equipment may be supplied to a higher principal construction code than required.

Note 2 - Filters may be downsized as operational needs dictate.

Note 3.-Table specifies nominal flow, temperature and capacity values.

TABLE 9.3-10 FAILURE MODE AND EFFECTS ANALYSIS - CHEMICAL AND VOLUME CONTROL SYSTEM ACTIVE COMPONENTS - NORMAL PLANT OPERATION AND SAFE SHUTDOWN

Component	Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
1. Air diaphragm operated globe valve BGLCV0459 (BGLCV0460 analogous)	a. Fails open	Charging and volume control - letdown flow	Failure reduces redundancy of providing letdown flow isolation to protect PRZ heaters from uncovering at low water level in the PRZ. No effect on system operation. Alternate isolation valve (BGLCV0460) provides back-up letdown flow isolation.	Valve position indication (open to closed position change) at CB.	Valve is designed to fail "closed" and is electrically wired so that the electrical solenoid of the air diaphragm operator is energized to open the valve. Solenoid is de-energized to close the valve upon the generation of a low level PRZ control signal. The valve is electrically interlocked with three letdown orifice isolation valves and may not be opened manually from the CB is any of these valves is at an open position.
	b. Fails closed	Charging and volume control - letdown flow	Failure blocks normal letdown flow to VCT. Minimum letdown flow requirements for boration of RCS to safe shutdown concentration level may be met by establishing letdown flow through alternate excess letdown flow path. If the alternate excess letdown flow path to VCT is not available due to single failure (loss of instrument air supply) affecting the opening operation of valves in each flow path, the plant operator can borate the RCS to a safe shutdown concentration level without letdown flow by utilizing the steam space available in the PRZ.	Valve position indication (closed to open position change) at CB; letdown flow temperature indication (BGTI0127) at CB; letdown flow-pressure indication (BGPI0131) at CB; letdown flow indication (BGFI0132) at CB; and VCT level indication (BGLI0185) and low water level alarm at CB.	

* See list at end of table for definition of acronyms and abbreviations used.

** As part of plant operation, periodic tests, surveillance inspections and instrument calibrations are made to monitor equipment and performance. Failures may be detected during such monitoring of equipment in addition to detection methods noted.

TABLE 9.3-10 (Sheet 2)

	Component	Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
2.	Air diaphragm operated globe valve BGHV8149B (BGHV8149C and BGHV8149A analogous)	a. Fails open	Charging and volume control - letdown flow	Failure prevents isolation of normal letdown flow through regenerative heat exchanger when bringing the reactor to a cold shutdown condition after the RHRS is placed into operation. Containment isolation valve BGHV8152 or BGHV8160 may be remotely closed from the CB to isolate letdown flow through the heat exchanger.	Vale position indication (open to closed position change) at CB.	Valve is of similar design as that stated for item 1. Solenoid is deenergized to close the valve upon the generation of a low water level PRZ signal or closing of letdown isolation valves BGLCV0459 and BGLCV0460 upstream of the regenerative heat exchanger.
		b. Fails closed	Charging and volume control - letdown flow	Failure blocks normal letdown flow to VCT. Normal letdown flow to VCT may be maintained by opening alternate letdown orifice isolation valve BGHV8149C. Minimum letdown flow requirements for boration of RCS to safe shutdown concentration level may be met by opening letdown orifice isolation valve BGHV8149A or BGHV8149C. If a single failure (loss of instrument air) prevents opening of these valves the plant operator can borate the RCS to a safe shutdown concentration level without letdown flow by utilizing the steam space available in PRZ.	Same methods of detection as those stated for item 1.b.	
3.	Air diaphragm operated globe valve BGHV8152 (BGHV8160 analogous)	a. Fails closed	Charging and volume control - letdown flow	Same effect on system operation as that stated for item 1.b.	Same methods of detection as those stated for item 1.b. In addition, close position group monitoring light at CB.	Valve is of similar design as that stated for item 1. Solenoid is deenergized to close the valve upon the generation of an CIS-A signal.
		b. Fails open	Charging and volume control - letdown flow	Failure has no effect on CVCS operation during normal plant operation and load follow. However, under accident conditions requiring containment isolation, failure reduces the redundancy of providing isolation of normal letdown line.	Valve position indication (open to closed position change) at CB.	

TABLE 9.3-10 (Sheet 3)

	Component	Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
4.	Air diaphragm operated globe valve BGTCV0381B	a. Fails open	Boron concentration control - boron thermal regeneration (boration)	Failure inhibits use of BTRS for load follow operation (boration) due to low temperature of letdown flow entering BTRS demineralizers. Alternate boration of reactor coolant for load follow is possible, using RMCS of CVCS. No effect of operations to bring reactor to safe shutdown condition.	Letdown heat exchanger tube discharge flow (BGFI0132) and pressure (BGPI0131) indications at CB and BTR demineralizer inlet flow temperature indication (BGTI0381) at CB if BTRS is in operation.	1. Valve is designed to fail "open" and is electrically wired so that the electrical solenoid of the air diaphragm operator is energized to close the valve. 2. BTRS operation is not required in operations of the CVCS used to bring the reactor to hot standby condition.
		b. Fails closed	Boron concentration control - boron thermal regeneration (boration)	Failure inhibits use of BTRS for load follow operation (boration) due to loss of temperature control of letdown flow entering BTRS demineralizers. Failure also blocks normal letdown flow to VCT when BTRS is not being used for load follow. Minimum letdown flow requirements for boration of RCS to hot standby concentration level may be met as stated for effect on system operation for item 1.b.	Same methods of detection as those stated for item 1.b, except no "closed to open position change" indication at CB. If BTRS is not operating, BTRS status indication (off) light at CB.	
5.	Air diaphragm operated globe valve BGPCV0131	a. Fails open	Charging and volume control - letdown flow	Failure prevents control of pressure to prevent flashing of letdown flow in letdown heat exchanger and also allows high pressure fluid to mixed bed demineralizers. Relief valve BG8119 opens in demineralizer line to release pressure to VCT and valve BGTCV0129 changes position to divert flow to VCT. Boration of RCS to safe shutdown concentration level is possible with valve failing open.	Letdown heat exchanger tube discharge flow indication (BGFI0132) and high flow alarm at CB; temperature indication (BGTI0130) and high temperature alarm at CB; and pressure indication (BGPI0131) at CB.	1. Same remark as stated for item 4, in regard to valve design. 2. As a design transient the letdown heat exchanger is designed for complete loss of charging flow.
		b. Fails closed	Charging and volume control - letdown flow	Same effect on system operations as that stated for item 1.b.	Letdown heat exchanger discharge flow indication (BGFI0132), pressure indication (BGPI0131) and high pressure alarm at CB.	

TABLE 9.3-10 (Sheet 4)

	Component	Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
6.	Air diaphragm operated three way valve BGTCV0129	a. Fails open for flow only to VCT	Charging and volume control - letdown flow	Letdown flow bypassed from flowing to mixed bed demineralizers and BTRS. Failure prevents ionic purification of letdown flow and inhibits operation of BTRS. Boration of RCS to safe shutdown concentration level is possible with valve failing open for flow only to VCT.	Valve position indication (VCT) at CB and RCS activity level when sampling letdown flow.	1. Electrical solenoid of air diaphragm operator is electrically wired so that solenoid is energized to open valve for flow to the mixed bed demineralizers. Valve opens for flow to VCT on "high letdown temperature" or on "high letdown reheat heat exchanger outlet temperature." 2. Technical Specifications provide limits on RCS activity.
		b. Fails open for flow only to mixed bed demineralizer	Charging and volume control - letdown flow	Continuous letdown to mixed bed demineralizers and BTRS. Failure prevents automatic isolation of mixed bed demineralizers and BTRS under fault condition of high letdown flow temperatures. These systems may be manually isolated, using local valves BG8524A and BG8524B at mixed bed demineralizers. Boration of RCS to safe shutdown concentration level is possible with valve failing open for flow only to demineralizer.	Valve position indication (demineralizer) at CB. If BTRS is in operation, BTR demineralizer return flow indication (BGFI0385) indicating flow during an alarm condition of high letdown reheat heat exchanger outlet temperature or high letdown temperature.	
7.	Air diaphragm operated diaphragm valve BGHV7054	Fails closed	Boron concentration control - boron thermal regeneration or storage	Failure inhibits use of BTRS for load follow operation (boration or dilution) due to flow isolation of the BTRS. Alternate boration or dilution of reactor coolant for load follow may be accomplished using RMCS of CVCS. No effect on operation to bring reactor to safe shutdown condition.	Valve position indication (closed to open position change) at CB; BTRS operation indication (borate or dilute) at CB and BTR demineralizer return flow indication (BGFI0385) and inlet flow temperature indication (BGTI0381) at CB.	1. Valve is designed to fail "closed" and is electrically wired so that the electrical solenoid of air diaphragm operator is energized to open the valve. 2. BTRS not required to bring reactor to safe shutdown condition.

TABLE 9.3-10 (Sheet 5)

	Component	Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
8.	Air diaphragm operated diaphragm valve BGUV7002A	a. Fails closed	Boron concentration control - boron storage	Failure inhibits use of BTRS for load follow operation (dilution) due to flow isolation of letdown chiller heat exchanger. Alternate dilution of reactor coolant for load follow may be accomplished using RMCS of CVCS. No effect on operations to bring reactor to safe shutdown condition.	BTRS operation indication (dilute) at CB; letdown reheat heat exchanger outlet temperature (BGTI0381) at CB; and RCS boron level when sampling letdown flow.	Same remarks as those stated for item 7.
		b. Fails open	Boron concentration control - boron thermal regeneration	Failure inhibits use of BTRS for load follow operation (boration) due to flow through letdown chiller heat exchanger. Alternate boration of reactor coolant for load follow may be accomplished using RMCS of CVCS. No effect on operation to bring reactor to safe shutdown condition.	BTRS operation indication (boration) at CB; BTRS return flow temperature indication (BGTI0386) at CB; BTR return flow indication (BGFI0385) at CB; and RCS boron level when sampling letdown flow.	
9.	Air diaphragm operated diaphragm valve BGUV7002B	a. Fails closed	Boron concentration control - boron storage	Same effect on system operation as that stated for item 8.a.	Same methods of detection as those stated for item 8.a.	Same remarks as those stated for item 7.
		b. Fails open	Boron concentration control - boron thermal regeneration	Failure inhibits use of BTRS for load follow operation (boration) due to bypass of letdown flow from letdown reheat heat exchanger. Alternate boration of reactor coolant may be accomplished, using RMCS of CVCS. No effect on operation to bring reactor to safe shutdown condition.	Same methods of detection as those stated for item 8.b.	
10.	Relief valve BG8117	Fails open	Charging and volume control - letdown flow	Letdown flow is relieved to pressurizer relief tank. Failure inhibits use of demineralizers for reactor coolant purification and use of BTRS. Normal letdown line can be isolated and minimum letdown flow requirements for hot standby may be met by establishing letdown flow through alternate excess letdown flow path.	High temperature relief line indication (BGTI0125) and alarm at CB and VCT level indication (BGLI0185) and low level alarm at CB.	Radioactive fluid contained.

TABLE 9.3-10 (Sheet 6)

	Component	Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
11.	Relief valve BG8119	Fails open	Charging and volume control - letdown flow	Letdown flow is relieved to VCT. Failure inhibits use of demineralizers for reactor coolant purification and use of BTRS. Normal letdown line can be isolated and minimum letdown flow requirement for hot standby may be met by establishing flow through alternate excess letdown flow path.	RCS activity level when sampling letdown flow. When BTRS is operating, low BTR demineralizer return flow indication (BGFI0385) at CB.	Radioactive fluid contained.
12.	Air diaphragm operated diaphragm valve BGHV8245	a. Fails closed	Boron concentration control - boron thermal regeneration or storage	Normal purification of reactor coolant using only mixed bed demineralizers cannot be performed. Failure also blocks normal letdown flow. Boration of RCS to safe shutdown concentration level may be met as stated for effect on system operation for item 1.b.	BTRS operation indication (off) at CB and RCS activity level when sampling letdown flow. Valve position indication (closed to open position change) at CB.	Same remarks as those stated for item 4.
		b. Fails open	Boron concentration control - boron thermal regeneration or storage	Failure inhibits use of BTRS for load follow operation (boration or dilution) due to bypass of letdown flow from BTRS. Alternate boration or dilution of reactor coolant for load follow may be accomplished using RMCS of CVCS. No effect on operations to bring reactor to hot standby condition.	RCS boron level when sampling letdown flow. If BTRS is operating, BTRS operating indication (borate or dilute) at CB and low BTR demineralizer return flow indication (BGFI0385) at CB. Valve position indication (open to closed position change) at CB.	
13.	Air diaphragm operated diaphragm valve BGUV7045 (BGUV7056 analogous)	a. Fails closed	Boron concentration control - boron storage	Failure inhibits use of BTRS for load follow operation (dilution) due to flow isolation of BTR demineralizers. Alternate dilution of reactor coolant for load follow may be accomplished, using RMCS of CVCS. No effect on operations to bring reactor to safe shutdown condition.	RCS boron level when sampling letdown flow. If BTRS is operating, BTRS operation indication (dilute) at CB and low BTR demineralizer return flow indication (BGFI0385) at CB.	Same remarks as those stated for item 7 regarding BGUV7056. Same remarks as those stated for item 4 regarding BGUV7045..

TABLE 9.3-10 (Sheet 7)

Component	Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
	b. Fails open	Boron concentration control - boron thermal regeneration	Failure inhibits use of BTRS for load follow operation (boration) due to flow bypass of BTR demineralizers. Alternate boration of reactor coolant for load follow may be accomplished using RMCS of CVCS. No effect on operations to bring reactor to safe shutdown condition.	RCS boron level when sampling letdown flow. If BTRS is operating, BTRS operation indication (borate) at CB.	
14. Air diaphragm operated diaphragm valve BGUV7057 (BGUV7046 analogous)	a. Fails open	Boron concentration control - boron storage	Failure inhibits use of BTRS for load follow operation (dilution) due to flow bypass of BTR demineralizers. Alternate dilution of reactor coolant for load follow may be accomplished using RMCS of CVCS. No effect on operations to bring reactor to safe shutdown condition.	RCS boron level when sampling letdown flow. If BTRS is operating, BTRS operation indication (dilute) at CB.	Same remarks as those stated for item 4 regarding BGUV7057. Same remarks as those stated in item 7 regarding BGUV7046.
	b. Fails closed	Boron concentration control - boron thermal regeneration	Failure inhibits use of BTRS for load follow operation (boration) due to flow isolation of BTR demineralizers. Alternate boration of reactor coolant for load follow may be accomplished, using RMCS of CVCS. No effect on operations to bring reactor to safe shutdown condition.	RCS boron level when sampling letdown flow. If BTRS is operating, BTRS operation indication (borate) at CB and low BTR demineralizer return flow indication (BGFI0385) at CB.	
15. Air diaphragm operated diaphragm valve BGUV7040	a. Fails open	Boron concentration control - boron storage	Same effect on system operation as that stated for item 14.a.	Same methods of detection as those stated for item 14.a.	Same remarks as those stated for item 4.
	b. Fails closed	Boron concentration control - boron thermal regeneration	Failure inhibits use of BTRS for load follow operation (boration) due to blockage of return letdown flow from letdown chiller heat exchanger. Alternate boration of reactor coolant for load follow may be accomplished, using RMCS of CVCS. No effect on operations to bring reactor to hot standby condition.	Same methods of detection as those stated for item 14.b.	

TABLE 9.3-10 (Sheet 8)

Component	Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
16. Air diaphragm operated diaphragm valve BGUV7041	a. Fails open	Boron concentration control - boron storage	Failure inhibits use of BTRS for load follow operation (dilution) due to flow bypass of letdown chiller heat exchanger. Alternate dilution of reactor coolant for load follow may be accomplished, using RMCS of CVCS. No effect on operation to bring reactor to safe shutdown condition.	RCS boron level when sampling letdown flow. If BTRS is operating, BTRS operation indication (dilute) at CB and letdown reheat heat exchanger outlet temperature indication (BGTI0381) at CB.	Same remarks as those stated for item 4.
	b. Fails closed	Boron concentration control - boron thermal regeneration	Failure inhibits use of BTRS for load follow operation (boration) due to flow isolation of letdown reheat heat exchanger and BTR demineralizers. Alternate boration of reactor coolant for load follow may be accomplished using RMCS of CVCS. No effect on operation to bring reactor to safe shutdown condition.	Same methods of detection as those stated for item 14.b.	
17. Air diaphragm operated diaphragm valve BGUV7022	a. Fails closed	Boron concentration control - boron storage	Failure inhibits use of BTRS for load follow operation (dilution) due to flow blockage of return letdown flow from moderating heat exchanger. Alternate dilution of reactor coolant for load follow may be accomplished, using RMCS of CVCS. No effect on operation to bring reactor to safe shutdown condition.	RCS boron level when sampling letdown flow. If BTRS is operating, BTRS operation indication (dilute) at CB and low BTR demineralizer return flow indication (BGFI0385) at CB.	Same remarks as those stated for item 7.
	b. Fails open	Boron concentration control - boron thermal regeneration	Failure inhibits use of BTRS for load follow operation (boration) due to bypass of flow from letdown chiller heat exchanger of return letdown flow. Alternate boration of reactor coolant for load follow may be accomplished, using RMCS of CVCS. No effect on operation to bring reactor to safe shutdown condition.	RCS boron level when sampling letdown flow. If BTRS is operating, BTRS operate indication (borate) at CB and BTRS return flow temperature indication (BGTI0386) and high temperature alarm at CB.	

TABLE 9.3-10 (Sheet 9)

	Component	Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
18.	Air diaphragm operated butterfly valve BGTCV0386	Fails closed	Boron concentration control - boron thermal regeneration and storage	Failure inhibits use of BTRS for load follow operation (boration and dilution) due to flow blockage of chiller flow through letdown chiller heat exchanger. Alternate boration and dilution of reactor coolant for load follow may be accomplished, using RMCS of CVCS. No effect on operations to bring reactor to safe shutdown condition.	RCS boron level when sampling letdown flow. If BTRS is operating, BTRS return flow temperature indication (BGTI0386) and high temperature alarm at CB; and chiller surge tank temperature indication (BGTI0379) at CB.	1. Valve is designed to fail "closed." 2. BTRS not used to bring the reactor to safe shutdown condition.
19.	Air diaphragm operated butterfly valve (BGFCV0375	Fails open	Boron concentration control - boron thermal regeneration and storage	Failure inhibits use of BTRS for load follow operation (boration and dilution) due to flow bypass of chiller flow from letdown chiller heat exchanger. Alternate boration and dilution of reactor coolant for load follow may be accomplished, using RMCS of CVCS. No effect on operations to bring reactor to safe shutdown condition.	RCS boron level when sampling letdown flow. If BTRS is operating, BTRS return flow temperature indication (BGTI0386) and high temperature alarm at CB and chiller surge tank temperature indication (BGTI0379) at CB.	1. Valve is designed to fail "open." 2. BTRS not used to bring the reactor to safe shutdown condition.
20.	Chiller unit, AHCU	Fails to cool liquid	Boron concentration control - boron thermal regeneration and storage	Failure inhibits use of BTRS for load follow operation (boration and dilution) due to loss of cooling capability of letdown chiller heat exchanger. Alternate boration and dilution of reactor coolant for load follow may be accomplished, using RMCS of CVCS. No effect on operations to bring reactor to hot standby condition.	Same methods of detection as those stated for item 19. In addition, BTRS operation indication (borate or dilute) at CB.	BTRS not used to bring the reactor to safe shutdown condition.
21.	Chiller pump 1, APCI (pump 2 analogous)	Fails to deliver working fluid	Boron concentration control - boron thermal regeneration and storage	No effect on BTRS operation. Redundant chiller pump 2 provides necessary delivery of working fluid for chiller unit operation. BTRS not required in operations to bring reactor to hot standby condition.	Local pump discharge flow pressure indication (BGPI0377A) and MCC contactor position indication (open) at CB.	Both chiller pumps operate simultaneously during BTRS operation.

TABLE 9.3-10 (Sheet 10)

	Component		Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
22.	Air diaphragm operated diaphragm valve BGTCV0381A	a.	Fails closed	Boron concentration control - boron thermal regeneration and storage	Failure inhibits use of BTRS for load follow operation (boration) due to flow isolation of tube side of letdown reheat heat exchanger. Alternate boration of reactor coolant for load follow may be accomplished using RMCS of CVCS. No effect on operations to bring reactor to safe shutdown condition.	RCS boron level when sampling letdown flow. If BTRS is operating, letdown reheat heat exchanger outlet temperature indication (BGTI0381) at CB.	Same remarks as those stated for item 7.
		b.	Fails open	Boron concentration control - boron storage	Failure inhibits use of BTRS for load follow operation (dilution) due to passage of CVCS letdown flow through tube side of letdown reheat heat exchanger. Alternate dilution of reactor coolant may be accomplished using RMCS of CVCS. No effect on operations to bring reactor to safe shutdown condition.	RCS boron level when sampling letdown flow. If BTRS is operating, letdown reheat heat exchanger outlet temperature indication (BGTI0381) at CB.	
23.	Solenoid operated globe valve BGHV8153A (BGHV8154A analogous; BGHV8153B and BGHV8154B similar)	a.	Fails closed	Charging and volume control - letdown flow	Failure reduces redundancy of the excess letdown fluid system of the CVCS as an alternate system that may be used for letdown flow control during normal plant operation and reduces redundancy of the excess letdown system to control water level in the pressurizer of the RCS during final stage of plant startup due to flow blockage.	Valve open/closed position indication at CB; letdown high temperature indication and alarm at CB.	1. If normal letdown and excess flow is not available for safe shutdown operations, plant operator can borate RCS to safe shutdown concentration, using steam space available in PRZ.
		b.	Fails open	Charging and volume control - letdown flow	Failure reduces redundancy of providing excess letdown flow isolation during normal plant operation and for plant startup. No effect on system operation. Alternate isolation valves closed to provide back-up flow isolation of excess letdown line.	Valve position indication (open to closed position change) at CB.	
24.	Air diaphragm operated globe valve BGHCV0123	a.	Fails closed	Charging and volume control - letdown flow	Same effect on system operation as that stated for item 23.a. Redundant valves BBHV8157A or BBHV8157B may be opened to provide a path to the PRT.	Same methods of detection as those stated for item 23.a,	Same remarks as those stated for item 23. except for valve position indication at CB.

TABLE 9.3-10 (Sheet 11)

Component	Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
	b. Fails open	Charging and volume control - letdown flow	Failure prevents manual adjustment at CB of RCS pressure downstream of excess letdown heat exchanger to a low pressure consistent with number 1 seal leakoff backpressure requirements. When using excess letdown system, failure leads to a decrease in seal water pump shaft flow for cooling pump bearings.	Excess letdown heat exchanger outlet pressure indication (BGPI0124) at CB, and seal water return flow recording (BGFR0156) and low flow alarm at CB.	
25. Air diaphragm operated diaphragm valve BBLCV0181 (BBLCV0178, BBLCV0179 and BBLCV0180 analogous)	a. Fails closed	Charging and volume control - seal water flow	No automatic makeup of seal water to seal water to seal standpipe that services number 3 seal of RC pump 1. No effect on operations to bring the reactor to safe shutdown condition.	Valve position indication (closed to open position change) and low standpipe level alarm at CB.	1. Same remark as that stated for item 7 in regard to valve design. 2. Low level standpipe alarm conservatively set to allow additional time for RC pump operation without a complete loss of seal water from being injected to number 3 seal after sounding of alarm.
	b. Fails open	Charging and volume control - seal water flow	Overfill of seal water standpipe and dumping of reactor makeup water to containment normal sump during automatic makeup of water for number 3 seal of RC pump 1. No effect on operations to bring reactor to safe shutdown condition.	Valve position indication (open to closed position change) and high standpipe level alarm at CB.	
26. Relief valve BG8121	Fails open	Charging and volume control - seal water flow	RC pump seal water return flow and normal excess letdown flow bypassed to PRZ relief tank of RCS. Failure inhibits use of the excess letdown fluid system of the CVCS as an alternate system that may be used for letdown flow control during normal plant operation and inhibits use of normal excess letdown system to control water level in the PRZ of the RCS during final stage of a plant startup.	Decrease in VCT level, causing RMCS of CVCS to operate.	1. The capacity of the relief valve equals maximum flow from four RC pump seals plus normal excess letdown flow. 2. Radioactive fluid contained. 3. Same remark as that stated for item 23.

TABLE 9.3-10 (Sheet 12)

Component	Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
27. Motor-operated globe valve BGHV8112 (BGHV8100 analogous)	a. Fails open	Charging and volume control - seal water flow and excess letdown flow	Failure has no effect on CVCS operation during normal plant operation and load follow. However, under accident conditions requiring containment isolation, failure reduces redundancy of providing isolation of seal water flow and normal excess letdown flow.	Valve position indication (open to closed position change) at CB.	1. Valve is normally at a full open position, and motor operator is energized to close the valve upon the generation of a containment isolation signal. 2. If normal letdown and normal excess letdown flow is not available for safe shutdown operation, plant operator can borate RCS to safe shutdown concentration, using steam space available in PRZ and excess letdown path to PRT.
	b. Fails closed	Charging and volume control - seal water flow and excess letdown flow	RC pump seal water return flow and normal excess letdown flow blocked. Failure inhibits use of the normal excess letdown fluid system of the CVCS as an alternate system that may be used for letdown flow control during normal plant operation. However, excess letdown path to PRT will be available along with increased steam space in PRZ. Also degrades cooling capability of seal water in cooling RC pump bearings. CCW should be established to the seals and seal injection terminated. This minimizes water loss to PRT via relief valve BG8121. Valve BG8121 will continue to pass seal leakage to PRT (5 gpm per seal) until the RCS pressure is reduced.	Valve position indication (closed to open position change) at CB; group monitoring light at CB; and seal water return flow recording (BGFR0157) and low seal water return flow alarm at CB.	

TABLE 9.3-10 (Sheet 13)

Component	Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
28. Motor-operated gate valve BGHV8105 (BGHV8106 analogous)	a. Fails open	Charging and volume control - charging flow	Failure has no effect on CVCS operation during normal plant operation and load follow. However, under accident conditions requiring isolation of charging line, failure reduces redundancy of providing isolation of normal charging flow.	Valve position indication (open to position change) at CB.	Valve is normally at a full open position, and motor operator is energized to close the valve upon the generation of a safety injection signal.
	b. Fails closed	Charging and volume control - charging flow	Failure inhibits use of normal charging line to RCS for boration, dilution, and coolant makeup operations. Seal water injection and Boron Injection paths remain available for boration of RCS to a safe shutdown concentration level and makeup of coolant during operations to bring the reactor to safe shutdown condition.	Valve position indication (closed to open position change) and group monitoring light (valve closed) at CB; letdown temperature indication (BGTI0127) and high temperature alarm at CB; charging flow temperature indication (BGTI0126) at CB; seal water flow pressure indication (BGPI0120A) at CB; VCT level indication (BGLI0185) and high level alarm at CB.	
29. Air diaphragm operated globe valve BGHCV0182	a. Fails open	Charging and volume control - charging flow and seal water flow	Failure prevents manual adjustment at CB of seal water flow through the control of backpressure in charging header, resulting in a reduction of flow to RC pump seals leading to a reduction in flow to RCS via labyrinth seals and pump shaft flow for cooling pump bearings. Boration of RCS to a safe shutdown concentration level and makeup of coolant during operations to bring reactor to safe shutdown condition is still possible through normal charging flow path or the Boron Injection path.	Seal water flow pressure indication (BGPI0120A) at CB; seal water return recording (BGFR0157); and low seal water return flow alarm at CB.	Same remark as that stated for item 4 in regard to design of valve.
	b. Fails closed	Charging and volume control - charging flow	Same effect on system operation as that stated for item 28.b.	Same methods of detection as those stated for item 28.b.	

TABLE 9.3-10 (Sheet 14)

Component	Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
30. Motor-operated globe valve BGHV8110 (BGHV8111 analogous)	a. Fails open	Charging and volume control - charging flow and seal water flow	Failure has no effect on CVCS operation during normal plant operation and load follow. However, under accident conditions requiring isolation of ECCS centrifugal charging pump miniflow line to suction of pumps via seal water heat exchanger, failure results in reduction of delivered flow for one 100 percent train only.	Valve position indication (open to closed position change) at CB.	1. Same remarks as those stated for item 28.
	b. Fails closed	Charging and volume control - charging flow and seal water flow	Failure blocks miniflow to suction of ECCS centrifugal charging pumps via seal water heat exchanger. Normal charging flow prevents deadheading of pumps when used. Boration of RCS to a safe shutdown concentration level and makeup of coolant during operations to bring reactor to safe shutdown condition is accomplished by the opposite train which provides 100 percent of the flow requirements.	Valve position indication (closed to open position change) at CB; group monitoring light (valve closed) and alarm at CB; and charging and seal water flow indication (BGFI0121A) and high flow alarm at CB.	
31. Air diaphragm operated globe valve BGHV8146	a. Fails open	Charging and volume control - charging flow	Failure has no effect on CVCS operation during normal plant operation, load follow, and safe shutdown operation. Valve is used during cold shutdown operation to isolate normal charging line when using the auxiliary spray during the cooldown of the PRZ. Cold shutdown of reactor is still possible; however, time for cooling down the PRZ will be extended.	Valve position indication (open to closed position change) at CB.	Same remark as that stated for item 4 in regard to design of valve.

TABLE 9.3-10 (Sheet 15)

Component	Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
	b. Fails closed	Charging and volume control - charging flow	Failure blocks normal charging flow to the RCS. No effect on CVCS operations during normal plant operation, load follow, or safe shutdown operation. Plant operator can maintain charging flow by establishing flow through alternate charging path by opening isolation valve BGHV8147.	Valve position indication (closed to open position change) at CB; charging flow temperature indication (BGTI0126) at CB; regenerative heat exchanger shell side exit temperature indication (BGTI0127) and high temperature alarm at CB; and charging and seal water flow indication (BGFI0121A) and low flow alarm at CB.	
32. Air diaphragm operated glove valve BGHV8147	a. Fails closed	Charging and volume control - charging flow	Failure reduces redundancy of charging flow paths to RCS. No effect on CVCS operations during normal plant operation, load follow, or safe shutdown operation. Normal charging flow path remains available for charging flow.	Valve position indication (closed to open position change) at CB.	Same remark as that stated for item 4 in regard to design of valve.
	b. Fails open	Charging and volume control - charging flow	Same effect on system operation and shutdown as that stated for item 31.a, if alternate charging line is in use.	Valve position indication (open to closed position change) at CB.	
33. Air diaphragm operated globe valve BGHV8145.	a. Fails open	Charging and volume control - charging flow	Failure results in inadvertent operation of auxiliary spray that results in a reduction of PRZ pressure during normal plant operation and load follow. PRZ heaters operate to maintain required PRZ pressure. Boration of RCS to a safe shutdown concentration level and makeup of coolant during operation to bring reactor to a safe shutdown condition is still possible.	Valve position indication (open to closed position change) at CB and PRZ pressure recording (BBPR0455) and low pressure alarm at CB.	Same remarks as that stated for item 7 in regard to design of valve.
	b. Fails closed	Charging and volume control - charging flow	Failure has no effect on CVCS operation during normal plant operation, load follow, and safe shutdown operation. Valve is used during cold shutdown operation to active auxiliary spray for cooling down the PRZ after operation of RHRS.	Valve position indication (closed to open position change) at CB.	

TABLE 9.3-10 (Sheet 16)

	Component	Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
34.	Relief valve BG8123	Fails open	Charging and volume control - charging flow	Failure results in a portion of seal water return flow and charging pump miniflow being bypassed to VCT. Boration of RCS to a safe shutdown concentration level and makeup of coolant during operations to bring reactor to safe shutdown condition is still possible.	Local pressure indication (BGPI0118, BGPI0390 and BGPI0119) in discharge line of charging pumps.	Radioactive fluid contained.
35.	Deleted					
36.	Air diaphragm operated globe valve BGFCV0121	a. Fails open	Charging and volume control - charging flow and seal water flow	Failure reduces redundancy of providing charging and seal water flow to RCS. Low flow in seal injection line will automatically start charging pumps and open diverse path. No effect on normal plant operation, load follow, or bringing reactor to safe shutdown condition. Normal charging pump normally used for delivery of charging and seal water flow to RCS. Check valves BG8481A and BG8481B along with BGV0606 and BGV0605 provide isolation of normal charging pump flow to discharge of ECCS centrifugal charging pump if valve fails "open" during operation of normal charging pump.	Charging and seal water flow indication (BGFI0121A) and high flow alarm at CB, and PRZ level recording (BBLR0459) and high level alarm at CB.	1. Same remark as that stated for item 4 in regard to design of valve. 2. Methods of detection apply when an ECCS centrifugal charging pump is in operation.
		b. Fails closed	Charging and volume control - charging flow and seal water flow	Failure reduces redundancy of providing charging and seal water flow to RCS. Low flow in seal injection line will automatically start charging pumps and open diverse path. No effect on system operation during normal plant operation load follow, or bringing reactor to safe shutdown condition. Normal charging pump normally used for delivery of charging and seal water flow to RCS.	Charging and seal water flow indication (BGFI0121A) and low flow alarm at CB, and PRZ level recording (BBLR0459) and low level alarm at CB.	

TABLE 9.3-10 (Sheet 17)

Component	Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
36a. Motor operated globe valve BGHV8357A (BGHV8357B analogous)	Fails as is	Charging and volume control - alternate seal water flow	Failure reduced redundancy of providing seal water flow during accident conditions. No effect on safety for system operation. Seal water flow under an accident condition is provided by alternate flow path through valve BGHV8357B (BGHV8357A).	Valve open/closed position indication at CB; seal water flow indication (BGFI0215A, BGFI0215B) at CB; seal water return recording (BGFR0157); and low seal water return flow alarm (BGFAL0154).	
37. Check valve BG8497 (BGV0645)	Fails open	Charging and volume control - charging flow and seal water flow	Failure reduces redundancy of providing charging and seal water to RCS. Discharge of normal charging pump still protected by redundant check valve BGV0645 (BG8497) against "back-flow" when an ECCS centrifugal charging pump is placed into operation. No effect on normal plant operation, load follow, or bringing reactor to safe shutdown condition; normal charging pump normally used for delivery of charging and seal water flow.	Failure of check valve would be detected during ASME OM Inservice testing.	1. Normal charging pump may be isolated by the closing of manual valves in pump's suction and discharge lines. 2. Methods of detection apply when PBG05A is in operation.
38. Check valve BG8481A (BG8481B analogous)	Fails open	Charging volume control - charging flow and seal water flow	Failure reduces redundancy of providing charging and seal water flow to RCS. Discharge of PBG05A is open to "backflow" when PBG05B is placed into operation after failure of PBG05A to deliver charging and seal water flow. No effect on normal plant operation, load follow, or bringing reactor to safe shutdown condition; normal charging pump normally used for delivery of charging and seal water flow. BGV0606 provides redundancy forBG8481A and BGV0605 provides redundancy for BGV08481B.	Same methods of detection as those stated for item 37.	1. PBG05A may be isolated by the closing of manual valves in pump's suction and discharge lines. 2. Methods of detection apply when PBG05B is in operation.

TABLE 9.3-10 (Sheet 18)

	Component	Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
39.	Normal charging pump PBG04	Fails to deliver working fluid	Charging and volume control - charging flow and seal water flow	Failure reduces redundancy of providing charging and seal water flow to RCS. No effect on normal plant operation, load follow, or bringing reactor to safe shutdown condition. Centrifugal charging pumps (PBG05A and PBG05B) are automatically placed into operation for delivery of charging and seal water flow.	Pump circuit breaker position indication (open) at CB; common pump breaker trip alarm at CB; charging and seal water flow indication (BGFI0121A) and low flow alarm at CB; and PRZ level recording (BBLR0459) and low level alarm at CB.	Pump flow is regulated by BGFCV0124 to control amount of charging flow delivered to the PRZ.
40.	Centrifugal charging pump PBG05A (PBG05B analogous)	Fails to deliver working fluid	Charging and volume control - charging flow and seal water flow	Failure reduces redundancy of providing charging and seal water flow to RCS. Alternate delivery of charging and seal water flow by redundant ECCS centrifugal charging pump is available. No effect on normal plant operation, load follow or bringing reactor to safe shutdown condition. Normal charging pump normally used for delivery of charging and seal water flow.	Same methods of detection as those stated for item 39 when PBG05A is in operation.	Flow rate for an ECCS centrifugal charging pump is controlled by a modulating valve (BGFCV0121) in discharge header for the ECCS centrifugal charging pumps. Flow rate for normal charging pump is controlled by BGFCV0124.
41.	Air diaphragm operated globe valve BG8156	Fails closed	Chemical control, purification, and makeup oxygen control	Failure blocks hydrogen flow to VCT and leads to loss of venting of FCT (vent line BGPCV0115 closes on low VCT pressure), resulting in loss of gas stripping of fission products from RCS coolant. No effect on operation to bring the reactor to safe shutdown condition.	VCT pressure indication (BGPI0115) and low pressure alarm at CB. Periodic sampling of gas mixture in VCT.	1. Valve is designed to fail "closed." 2. Plant Technical Specifications set limits on RCS activity level.
42.	Relief valve BG8120	Fails open	Charging and volume control charging flow and seal water flow	Failure allows VCT liquid to be released to BRS recycle holdup tank, resulting in a loss of VCT liquid and makeup coolant available for charging and seal water flow during normal plant operation, load follow, and bringing the reactor to a safe shutdown condition. VCT isolation valves BGLCV0112B and BGLCV0112C close on low low tank level signal, causing the suction of charging pumps to be transferred to the RWST for an alternate supply of borated coolant.	Decrease in VCT level, causing RMCS to operate; VCT level indication (BGLI0185) and low level alarm at CB; and BRS recycle holdup tank level increase.	Radioactive fluid contained.

TABLE 9.3-10 (Sheet 19)

Component	Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
43. Motor operated gate valve BGLCV0112B (BGLCV0112C analogous)	a. Fails open	Charging and volume control charging flow and seal water flow	Failure has no effect on CVCS operation during normal plant operation, load follow, and bringing reactor to a safe shutdown condition. However, under accident conditions requiring isolation of VCT, failure reduces redundancy of providing isolation for discharge line of VCT.	Valve position indication (open to closed position change) at CB.	During normal plant operation and load follow, valve is at a full open position and motor operator is energized to close the valve upon the generation of a VCT low low level signal or upon the generation of safety injection signal.
	b. Fails closed	Charging and volume control charging flow and seal water flow	Failure blocks fluid flow from VCT during normal plant operation, load follow, and when bringing the reactor to a safe shutdown condition. Alternate supply of borated coolant from the RWST to suction of charging pumps can be established from the CB by the operator through the opening of RWST isolation valves BNLCV0112D and BNLCV0112E.	Valve position indication (closed to open position change) at CB; group monitoring light and alarm (valve closed) at CB; charging and seal water flow indication (BGFI0121A) and low flow alarm at CB; and PRZ level recording (BBLR0459) and low level alarm at CB.	
44. Air diaphragm operated diaphragm valve BGPCV0115	Fails closed	Chemical control, purification, and makeup oxygen control	Failure blocks venting of VCT gas mixture to gas waste processing system (waste gas compressors) for stripping of fission products from RCS coolant during normal plant operation and load follow. No effect on operations to bring the reactor to safe shutdown condition.	Valve position indication (closed to open position change) at CB and VCT pressure indication (BGPI0115) at CB. Periodic sampling of gas mixture in VCT.	1. Same remark as that stated for item 7 in regard to valve design. 2. Same remark as that stated for item 41 in regard to RCS activity.
45. Air diaphragm operated diaphragm valve BGFCV0110B	a. Fails closed	Boron concentration control reactor makeup control, boration, automatic makeup, and alternate dilution.	Failure blocks fluid flow from reactor makeup control system for automatic boric acid addition and reactor water makeup during normal plant operation and load follow. Failure also reduces redundancy of fluid flow paths for dilution of RC by reactor makeup water and blocks fluid flow for boration of the RC when bringing the reactor to a safe shutdown condition. Boration (at BA tank boron concentration level) of RCS coolant to bring the reactor to safe shutdown condition may be possible by opening alternate BA tank isolation valve BGHV8104 at CB.	Valve position indication (closed to open position change) at CB; total makeup flow deviation alarm at CB; and VCT level indication (BGLI0185) and low level alarm at CB.	Same remark as that stated for item 7 in regard to valve design.

TABLE 9.3-10 (Sheet 20)

Component	Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
	b. Fails open	Boron concentration control - reactor makeup control, boration, automatic makeup, and alternate dilution	Failure allows for alternate dilute mode type operation for system operation of normal dilution of RCS coolant. No effect on CVCS operation during normal plant operation and load follow and when bringing the reactor to a safe shutdown condition.	Valve position indication (open to closed position change) at CB.	
46. Air diaphragm operated diaphragm valve BGFCV0111B	a. Fails closed	Boron concentration control - reactor makeup control, dilution, and alternate dilution	Failure blocks fluid flow from RMCS for dilution of RCS coolant during normal plant operation and load follow. No effect on CVCS operation. Operator can dilute RCS coolant by establishing "alternate dilute" mode of system operation. Dilution of RCS coolant not required when bringing the reactor to a safe shutdown condition.	Same methods of detection as those stated for item 45.a.	Same remark as that stated for item 7 in regard to valve design.
	b. Fails open	Boron concentration control - reactor makeup control, dilution, and alternate dilution	Failure allows for alternate dilute mode type operation for system operation of boration and automatic makeup of RCS coolant. No effect on CVCS operation during normal plant operation and load follow and when bringing the reactor to a safe shutdown operation.	Valve position indication (open to closed position change) at CB.	
47. Relief valve BG8124	Fails open	Charging and volume control - charging and seal water flow	Failure allows for a portion of flow to suction header of charging pumps to be relieved to BRS recycle holdup tank. Boration of RCS coolant to bring reactor to safe shutdown condition is still possible.	Decrease in VCT level, causing RMCS to operate; VCT level indication (BGLI0185) and low level alarm at CB; and BRS recycle holdup tank level increase.	Radioactive fluid contained.

TABLE 9.3-10 (Sheet 21)

	Component	Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
48.	Air diaphragm operated globe valve BGFCV0110A	a. Fails open	Boron concentration control - reactor makeup control, boration, and automatic makeup	Failure prevents the addition of a preselected quantity of concentrated boric acid solution at a preselected flow rate to the RCS coolant during normal plant operation, load follow, and when bringing the reactor to a safe shutdown condition. Boration to bring the reactor to a safe shutdown condition is possible; however, flow rate of solution from BA tanks cannot be automatically controlled.	Valve position indication (open to closed position change) at CB; and BA flow recording (BGFR0110) and flow deviation alarm at CB.	Same remark as that stated for item 4 in regard to valve design.
		b. Fails closed	Boron concentration control - reactor makeup control, boration, and automatic makeup	Failure blocks fluid flow of BA solution from BA tanks during normal plant operation, load follow, and when bringing the reactor to a safe shutdown condition. Boration (at BA tank boron concentration level) of RCS coolant to bring the reactor to safe shutdown condition may be possible by opening of alternate BA tank isolation valve BGHV8104 at CB.	Valve position indication (closed to open position change) at CB; and BA flow recording (BGFR0110) and flow deviation alarm at CB.	
49.	Air diaphragm operated globe valve BGFCV0111A	a. Fails closed	Boron concentration control - reactor makeup control, dilute, alternate dilute, and automatic makeup	Failure blocks fluid flow of water from RMCS during normal plant operation and load follow. No effect on system operation when bringing the reactor to a safe shutdown condition.	Valve position indication (closed to open position change) at CB; VCT level indication (BGLI0185) and low level alarm at CB; and makeup water flow recording (BGFR0110) and flow deviation alarm at CB.	Same remark as that stated for item 7 in regard to valve design.
		b. Fails open	Boron concentration control reactor makeup control, dilute, alternate dilute, and automatic makeup	Failure prevents the addition of a preselected quantity of water makeup at a preselected flow rate to the RCS coolant during normal plant operation and load follow. No effect on system operation when bringing the reactor to a safe shutdown condition.	Valve position indication (open to closed position change) at CB and makeup water flow recording (BGFR0110) and flow deviation alarm at CB.	

TABLE 9.3-10 (Sheet 22)

	Component	Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
50.	Motor operated globe valve BGHV8104	a. Fails closed	Boron concentration control reactor makeup control, boration, and automatic makeup	Failure reduces redundancy of flow paths for supplying BA solution from BA tanks to RCS via charging pumps. No effect on CVCS operation during normal plant operation, load follow, or safe shutdown operation. Normal flow path via RMCS may be available for boration of RCS coolant.	Valve position indication (closed to open position change) at CB and flow indication (BGFI0183A) at CB.	1. Valve is at a closed position during normal RMCS operation. 2. If both flow paths from BA tanks are blocked due to failure of isolation valves BGFCV0110A and BGHV8104, borated water from RWST is available by opening isolation valve BNLCV0112D or BNLCV0112E.
		b. Fails open	Boron concentration control reactor makeup control, boration, and automatic makeup	Failure prevents the addition of a preselected quantity of concentrated BA solution at a preselected flow rate to the RCS coolant during normal plant operation, load follow, and when bringing the reactor to a safe shutdown condition. Boration to bring the reactor to a safe shutdown condition is possible; however, flow rate of solution from BA tanks cannot be automatically controlled.	Valve position indication (open to closed position change) at CB and flow indication (BGFI0183A) at CB.	
51.	BA transfer pump 1, APBA (pump 2 analogous) PBG02A PBG02B	Fails to deliver working fluid	Boron concentration control reactor makeup control, boration, and automatic makeup	No effect on CVCS operation during normal plant operation, load follow, or bringing reactor to safe shutdown condition. Redundant BA transfer pump 2 provides necessary delivery of working fluid for CVCS operation.	Pump motor start relay position indication (open) at CB and local pump discharge pressure indication (BGPI0113).	Both BA transfer pumps operate simultaneously for RMCS boration operation.
52.	Air diaphragm operated three way valve BGLCV0112A	Fails open for flow only to BRS recycle holdup tank	Charging and volume control letdown flow	Failure bypasses normal letdown flow to BRS recycle holdup tank, resulting in excessive use of RMCS. No effect on operation to bring reactor to safe shutdown condition.	Valve position indication (holdup tank) at CB; VCT water level indication (BGLI0185) and low level alarm at CB; and increase water level in BRS recycle holdup tank.	Valve is designed to fail open for flow to VCT and is electrically wired so that electrical control solenoids for valve are energized for flow to BRS recycle holdup tank. Valve opens to flow to BRS recycle holdup tank on high VCT water level signal.

TABLE 9.3-10 (Sheet 23)

Component	Failure Mode	CVCS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks

List of acronyms and abbreviations

BA	-	Boric acid
BRS	-	Boron recycle system
BTR	-	Boron thermal regeneration
BTRS	-	Boron thermal regeneration system
CB	-	Control board
CVCS	-	Chemical and volume control system
MCC	-	Motor control center
PRZ	-	Pressurizer
RC	-	Reactor coolant
RCS	-	Reactor coolant system
RHRS	-	Residual heat removal system
RWST	-	Refueling water storage tank
RMCS	-	Reactor makeup control system
VCT	-	Volume control tank

Note: Portions of the CVCS are relied upon to perform as part of the safety-grade cold shutdown designs; therefore, see Section 5.4.7 and Appendix 5.4A for further discussions.

TABLE 9.3-11 SERVICE GAS REQUIREMENTS

Component Serviced with Nitrogen	Service Gas Function
Safety injection accumulator tanks	Cover gas, source of potential energy
Pressurizer relief tank	Cover gas
Volume control tank	Purge gas (during shutdown)
Spent resin tanks	Sluice spent resins to solid radwaste system
Gas decay tanks	Maintenance during shutdown
Feedwater heaters	Purge and cover gas during layup
Steam generator (shell side)	Purge and cover gas during layup
Auxiliary steam generator and reboiler	Purge and cover during layup
Chilled water expansion tank	Cover gas
Chemical addition tanks	Cover gas
Electrical penetration assemblies	Testing
Steam generator blowdown system	Chemical mixing in steam generators
Hydrogen recombiners	Purge gas
Back up compressed gas system accumulators	Source of potential energy
Condensate storage tank	Purge gas
Recycle Holdup Tanks	Injected, as needed, prior to draining to protect diaphragm from tears
Hardened condensate storage tank	Purge gas
Reactor coolant drain tank	Purge gas

TABLE 9.3-11 (Sheet 2)

Component Serviced with Hydrogen	Service Gas Function
Main generator	Cooling medium for generator field
Volume control tank	Recombine free oxygen and stripping agent
Reactor coolant drain tank	Cover gas (from two 194 SCF local cylinders outside containment)
Gaseous radwaste system hydrogen recombiners	Testing (from a portable 20 SCF storage cylinder)
Component Serviced with Carbon Dioxide	**Service Gas Function**
Main generator gas system	Atmospheric and hydrogen purge
Control bldg HVAC CO/CO_2 monitors	Testing (from three 0.243 ft^3 storage cylinders containing CO, CO_2 and N_2)
Component Serviced with Oxygen	**Service Gas Function**
Gaseous radwaste system hydrogen recombiners	Recombination with free H_2 from volume control tank and other miscellaneous sources

TABLE 9.3-12 LABORATORY GAS REQUIREMENTS

Type	Count Room and Hot Lab	Radwaste Lab	Cold Lab
Argon	Yes	No	No
Propane	Yes	No	Yes
Oxygen	Yes	No	No
Hydrogen	No	Yes	No
Nitrous oxide	Yes	No	No
P-10	Yes	No	No
Acetylene	Yes	No	No
Nitrogen	Yes	No	No
Helium	No	Yes	No

Bottle size - less than 300 pounds of gas.

TABLE 9.3-13 BORON RECYCLE SYSTEM PRINCIPAL COMPONENT DATA SUMMARY

Recycle Evaporator Feed Pumps	
Number	2
Design pressure, psig	150
Design temperature, °F	250
Design flow, gpm	30/100
Design head, ft	250/200
Material	Austenitic stainless steel
Design code (1)	MS
Recycle Holdup Tanks	
Number	2
Capacity, usable, gal	60,700
Design pressure	Atmospheric
Design temperature, °F	200
Material	Austenitic stainless steel
Design code (1)	API 650
Recycle Evaporator Feed Demineralizers	
Number	2
Design pressure, psig	300
Design temperature, °F	250
Design flow, gpm	120
Resin volume, ft^3	39 max.
Material	Austenitic stainless steel
Design code (1)	ASME VIII, Div. 1
Recycle Evaporator Condensate Demineralizer	
Number	1
Design pressure, psig	300
Design temperature, °F	250
Design flow, gpm	120
Resin volume, ft^3	39 max.
Material	Austenitic stainless steel
Design code (1)	ASME VIII, Div. 1
Recycle Evaporator Feed Filter	
Number	1
Design pressure, psig	300
Design temperature, °F	250

TABLE 9.3-13 (Sheet 2)

Design flow, gpm	250
Particle retention	98% of 3 micron size*
Material, vessel	Austenitic stainless steel
Design code [1]	ASME VIII, Div. 1
Recycle Evaporator Condensate Filter	
Number	1
Design pressure, psig	200
Design temperature, °F	250
Design flow, gpm	35
Particle retention	98% of 30 micron size*
Material, vessel	Austenitic stainless steel
Design code [1]	ASME VIII, Div. 1
Recyle Holdup Tank Vent Eductor	
Number	1
Design pressure, psig	150
Design temperature, °F	200
Suction flow, scfm	1 ± 0.2
Motive flow, scfm	40
Material	Carbon steel
Design code [1]	MS

Note 1- Table indicates the required code based on its safety-related importance as dictated by service and functional requirements and by the consequences of their failure. Note that the equipment may be supplied to a higher principal construction code than required.

* Filters may be downsized as operational needs dictate.

9.4 AIR CONDITIONING, HEATING, COOLING, AND VENTILATION

The following sections provide the design bases, descriptions, and evaluations of the HVAC systems for each of the buildings within the standardized power block. Section 3.11(B) provides a summary of the environmental conditions that result from the systems described herein. Table 9.4-1 provides the design outside ambient conditions.

9.4.1 CONTROL BUILDING HVAC

The control building HVAC systems consist of the control building supply and exhaust systems, the control room, Class 1E electrical equipment and access control air-conditioning systems, the access control exhaust system, and the counting room recirculation system.

The control building supply system provides conditioned outside air for ventilation and cooling to each level of the control building. The control building exhaust system provides a means of normal exhaust and of purging smoke following a postulated fire from the clean areas (radiation Zone A areas) of the control building.

The control room air-conditioning, including the control room filtration system and the control room pressurization system, provides a suitable atmosphere for personnel and equipment within the control room.

The Class 1E electrical equipment air-conditioning system provides a suitable environment for the Class 1E electrical equipment.

The access control air-conditioning system provides a suitable environment for personnel comfort. The access control exhaust system exhausts the potentially contaminated areas of the access control area and provides a means of purging smoke following a postulated fire.

The counting room recirculation system provides a suitable environment for personnel and equipment located in the counting room.

9.4.1.1 Design Bases

9.4.1.1.1 Safety Design Bases

The control room air-conditioning system, the Class 1E air-conditioning system, and portions of the control building supply, control building exhaust, and the access control exhaust systems are safety related and are required to function following a DBA and to achieve and maintain the plant in a safe shutdown condition.

SAFETY DESIGN BASIS ONE - The control room air-conditioning system, the Class 1E air-conditioning system, and the control building isolation provisions are protected from

the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, and external missiles (GDC-2).

SAFETY DESIGN BASIS TWO - The control room air-conditioning system, the Class 1E air-conditioning system, and the provisions for control building isolation are designed to remain functional after an SSE and to perform their intended functions following a postulated hazard, such as a fire, internal missiles, or pipe break (GDC-3 and 4).

SAFETY DESIGN BASIS THREE - Safety functions of the control building HVAC systems can be performed, assuming a single active component failure coincident with the loss of offsite power.

SAFETY DESIGN BASIS FOUR - Active components of the control building HVAC systems are capable of being tested during plant operation. Provisions are made to allow for inservice inspection of the ASME Section III components of the safety-related air-conditioning units at appropriate times specified in the ASME Boiler and Pressure Vessel Code, Section XI.

SAFETY DESIGN BASIS FIVE - The control room air-conditioning system, the Class 1E air-conditioning system, and the safety-related control building isolation provisions are designed and fabricated to codes consistent with the quality group classification assigned by Regulatory Guide 1.26 and the seismic category assigned by Regulatory Guide 1.29. The power supply and control functions are in accordance with Regulatory Guide 1.32.

SAFETY DESIGN BASIS SIX - The capability to isolate all nonsafety-related HVAC system penetrations of the control building boundary is provided so that the occupation and habitability of the control room, as discussed in Section 6.4, will not be compromised (GDC-2 and 19).

SAFETY DESIGN BASIS SEVEN - The control room air-conditioning system provides the control room with a conditioned atmosphere during all modes of plant operation, including post-accident operation (GDC-19). The control room filtration system and the control room pressurization system charcoal adsorbers comply with Regulatory Guide 1.52 to the extent discussed in Table 9.4-2.

SAFETY DESIGN BASIS EIGHT - The Class 1E electrical equipment air-conditioning system provides a suitable atmosphere for the Class 1E electrical switchgear during all modes of plant operation, including loss of preferred power and post-accident operation.

9.4.1.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - The control building supply system provides the necessary outside air needed for the required cooling and ventilating of the cable spreading rooms. The control building supply system also provides ventilation and supplemental cooling for each of the other levels of the control building. The control

building ventilation system is designed to provide fresh air ventilation at a minimum rate of 0.1 cfm per square foot of floor area.

POWER GENERATION DESIGN BASIS TWO - The control building exhaust system serves to remove from the control building the hydrogen generated by the batteries during normal operation.

POWER GENERATION DESIGN BASIS THREE - The access control air-conditioning system provides RP access control areas, and the nonvital electric equipment areas of the electrical and mechanical equipment level with an environment suitable for personnel comfort and electrical equipment operation.

POWER GENERATION DESIGN BASIS FOUR - The access control exhaust system collects and processes the effluents from the potentially contaminated regions of the access control area. The exhaust system is designed to meet the requirements of the discharge concentration limits of 10 CFR 20 and the as-low-as-reasonably-achievable dose objective of 10 CFR 50, Appendix I. The access control exhaust system charcoal adsorption train complies with Regulatory Guide 1.140, to the extent discussed in Table 9.4-3.

POWER GENERATION DESIGN BASIS FIVE - The counting room recirculation system provides adequate cooling, humidity control, and filtering of the counting room environment for personnel and equipment.

9.4.1.2 System Description

9.4.1.2.1 General Description

The control building HVAC systems are shown in Figure 9.4-1. The systems consist of the control building supply system, control room air-conditioning system with supplemental filtration and pressurization systems, Class 1E electrical equipment air-conditioning system, access control air-conditioning system, counting room recirculation system, control building exhaust system, and the access control exhaust system. The design conditions for these systems are presented in Table 3.11(B)-1. Potential radiation doses in the control room are discussed in Chapter 15.0.

The control building is serviced by an outside-air-supply system which provides fresh cooled or heated air to each of the various levels of the building. Self-contained air-conditioning units serve the control room elevation and the Class 1E electrical equipment floors. Local fan-coil units serve the access control floor and nonvital areas of the electrical and mechanical equipment level and the counting room.

All outside air intakes, both essential and nonessential, are provided with labyrinth missile barriers. The barriers are designed to withstand and absorb missile impacts and to prevent the propagation of a missile trajectory in line with essential equipment.

Two exhaust systems also service the building. The control building exhaust system takes suction from the clean areas of the building, and the access control exhaust system takes suction from the potentially contaminated areas of the access control floor. The control building exhaust system discharges directly to the atmosphere, while the access control exhaust system processes the exhaust air through charcoal adsorbers prior to discharging through the unit vent.

Based on the source terms provided in Section 11.1 and the dose evaluation provided in Section 11.3, the access control exhaust system meets the objective of 10 CFR 50, Appendix I, and the limits of 10 CFR 20.

9.4.1.2.2 Component Description

Codes and standards applicable to the control building HVAC systems are listed in Tables 3.2-1 and 9.4-4. The control room air-conditioning system, including the control room filtration and pressurization systems, the Class 1E air-conditioning system, and safety-related HVAC penetrations of the control building boundaries are designed and constructed in accordance with codes and standards comparable with quality group C. The control room ac system coils and condenser and the Class 1E electrical equipment ac system coils and condensers are designed and constructed in accordance with quality group C.

NONESSENTIAL AIR HANDLING UNITS - Those nonessential air handling units which make up a part of the control building HVAC system are the control building supply air unit, access control air-conditioning unit, and the counting room fan coil unit.

The control building supply air unit consists of a particulate filter, hot-water heating coil, chilled-water cooling coil, centrifugal fan, and electric motor driver.

The access control air-conditioning unit consists of a particulate filter, chilled-water cooling coil, centrifugal fan, and electric motor driver.

The counting room fan-coil unit consists of a chilled-water cooling coil, humidifying unit, centrifugal fan, and electric motor driver.

SAFETY-RELATED AIR HANDLING UNITS - The control building HVAC system contains two safety-related air handling units, the control room air-conditioning unit, and the Class 1E electrical equipment air-conditioning unit.

Both the control room air-conditioning unit and the Class 1E electrical equipment air-conditioning unit consist of high efficiency prefilters, a self-contained refrigeration system utilizing essential service water as the heat sink, centrifugal fans, and electric motor drivers.

NONESSENTIAL FILTER UNITS - The control building HVAC system contains two nonessential filter units, the access control filtration unit, and the counting room filter unit.

The access control filtration unit consists of moderate efficiency prefilters, HEPA filters, and charcoal adsorption beds.

The counting room filter unit consists of moderate efficiency prefilters and HEPA filters.

SAFETY-RELATED FILTER UNITS - Those safety-related filter units which are a part of the control building HVAC system are the control room filtration system filter adsorber units and the control room pressurization system filter adsorber units.

Each control room filtration system filter adsorber unit consists of moderate efficiency prefilters, HEPA filters, and charcoal adsorption beds.

Each control room pressurization system filter adsorber unit consists of a demister, electric heater, HEPA filters, and charcoal adsorption beds.

NONESSENTIAL FANS - There are two pairs of nonessential fans in the control building HVAC system -- the access control exhaust fans and the control building exhaust fans.

The access control exhaust fans are centrifugal fans with an electric motor driver.

The control building exhaust fans are vaneaxial fans with an electric motor driver.

SAFETY-RELATED FANS - The control building HVAC system contains two pairs of safety-related fans, the control room filtration system fans, and the control room pressurization system fans.

Both the control room filtration system fans and the control room pressurization system fans are centrifugal fans with electric motor drivers.

SUPPLEMENTAL HEATER - Supplemental heating is provided by nonessential electric duct heaters and electric unit heaters.

Electric duct heaters supplement the heating of the control room, access control area, the HVAC equipment room (El. 2,016), and the nonvital areas of the dc battery and switchgear area.

Electric unit heaters supplement the heating of the upper and lower cable spreading rooms, the ESF switchgear rooms, the pipe chase/tank area, and the control room air-conditioning equipment room. Each unit heater consists of a coil and a fan with an electric motor driver.

FIRE DAMPERS - Fire dampers are located between fire barriers, as necessary, to maintain the fire ratings of the barriers. Dampers are the 3-hour-rated curtain type.

ISOLATION DAMPERS - Where a means of system isolation is required, parallel-blade-type dampers are utilized. The type of operator employed is dependent upon the specific design and/or usage requirements.

The following specific criteria were included in the control room isolation damper procurement specification to ensure that the required leak-tightness is provided:

a. For dampers with a surface area equal to or greater than 2 ft^2, the maximum allowable leakage at a pressure differential of 6 inches w.g. is 20 cfm/ft^2.

b. For dampers with a surface area of less than 2 ft^2, but greater than 1 ft^2, the maximum allowable leakage at a differential pressure of 6 inches w.g. is 30 cfm/ft^2.

c. For dampers with a surface area of less than 1 ft^2, the maximum allowable leakage at a differential pressure of 6 inches w.g. is 30 cfm.

FLOW CONTROL DAMPERS - Opposed-blade-type dampers are utilized, as necessary, to provide a means of system balancing. In general, these are manually operated. However, some utilize power operators to allow compensation for changes occurring during system operation.

BACKDRAFT DAMPERS - Backdraft dampers are employed, where required, to maintain the proper direction of flow.

TORNADO DAMPERS - Tornado dampers are employed where isolation from the effects of extreme wind or tornado conditions is required. These dampers close with the flow produced by the differential pressure associated with the tornado or high winds.

9.4.1.2.3 System Operation

GENERAL - The control building is serviced by an outside air supply system which provides fresh cooled or heated air to each of the various levels of the building. Self-contained air-conditioning units serve the control room elevation and the Class 1E electrical equipment floors. Local fan-coil units serve the access control floor and the nonvital areas of the electrical and mechanical equipment level and the counting room.

Two exhaust systems also service the building. The control building exhaust system takes suction from the clean areas of the building, and the access control exhaust system takes suction from the potentially contaminated areas of the access control floor and the basement beneath. The control building exhaust system discharges directly to the atmosphere while the access control exhaust system processes the exhaust air through a charcoal adsorber train prior to discharging through the unit vent. The relative locations of all power block buildings and the location of the radiation release points are

shown on FSAR Figure 1.2-1. FSAR Figure 11.3-2 identifies the release points of potentially radioactive gaseous effluents.

Cooling water for the nonessential units is supplied by the central chilled water system (Section 9.4.10), and cooling water for the safety-related units is supplied by the essential service water system (Section 9.2.1). Hot water for the control building supply air unit is supplied by the plant heating system (Section 9.4.9).

Discussed below are the power generation operations, fire operation, and emergency operations of the control building HVAC systems. Shutdown operations are identical to the power generation operations.

POWER GENERATION OPERATION - The control building supply air system draws in outside air, filters it through low efficiency particulate filters, either cooling it with a chilled-water coil or heating it with a hot-water coil, and distributes the conditioned air to separate floors of the control building. The normal source of outside air is provided by the intake plenum located on top of the auxiliary building which is identified as an HVAC penthouse located between building column lines A-3 and A-1 and A-J and A-H on FSAR Figure 1.2-14.

The normal control building air intake is located approximately 113 feet horizontally and 138 feet below the unit vent discharge point, 385 feet horizontally and 15 feet above the radwaste building vent discharge point, and 39 feet (nearest exhaust vent) to 318 feet (farthest exhaust vent) horizontally and 57 feet below the turbine building exhaust fan discharge points.

The control building supply air system intake is in a penthouse atop the auxiliary building, which is located approximately 15 feet below and 135 feet horizontally from the diesel exhaust discharge point. This separation is sufficient to provide significant dilution of the diesel exhaust gases; therefore, operation of the diesel during normal plant operations poses no danger to the occupants of the control room or other areas of the building.

The heating or cooling mode of operation of the outside air supply unit is a function of the outside air temperature only. When the outside air temperature exceeds 65°F, conditioned outside air is supplied to the building. When the outside air temperature is between 65 and 50°F, unconditioned outside air is supplied to the building. When the outside air temperature is below 50°F, the heating system is operational. These operations are controlled by temperature switches, located in the ductwork upstream of the coils, which sense the outside air temperature and function accordingly.

When the outside air temperature rises above 65°F, the temperature switch associated with the cooling system activates the supply unit cooling control system. This control system then functions to maintain a constant supply air temperature of 60°F by modulating the flow of chilled water to the coil.

While the outside air temperature is between 65 and 50°F, the supply unit continues to operate, supplying unconditioned air to the building.

When the outside air temperature falls below 50°F, a temperature switch activates the supply unit heating control system. This control system then functions to maintain the temperature of the air leaving the coil at 65°F. The supply unit heating coil is supplied from a secondary hot-water loop to prevent the possible freezeup of the coil when the outside air temperature falls below 32°F. A temperature switch is provided in the outside air unit, downstream of the coils. This temperature switch will trip the supply unit, should the supply temperature drop below 40°F, to protect the coils from freezing.

Air from the control building supply system is supplied to the space above the access control area to remove the heat generated by electric cables. This cooling is provided to minimize the amount of cooling required for the spaces below. During periods of control building isolation, cooling is not required since the ambient temperature in the area will not exceed the ambient design rating (50°C) of the Class 1E power cables.

Supplemental heating for the access control area is provided by electric duct heaters located in the supply air mains serving that area. The heaters are interlocked with the supply fan, and operation of the heaters is controlled by room temperature switches which function to maintain space temperatures between 60 and 70°F.

Supplemental heating is also provided by electric unit heaters strategically located in the upper cable spreading room, the lower cable spreading room, the ESF switchgear rooms, the basement areas, and the control room air-conditioning equipment rooms. Each heater is sized for its specific location and is thermostatically controlled to maintain the space design temperature requirements of 60°F or above.

Air from the clean areas of the control building is exhausted by the control building exhaust system. Air from the potentially contaminated areas of the control building is exhausted by the access control exhaust system. Exhaust air from the access control exhaust system is processed through a charcoal filtration train for cleanup prior to discharge through the unit vent. Exhaust hoods are provided in the hot lab over the rinse sink and over the sample test area. The hoods in the hot lab contain an integral exhaust air bypass arrangement for periods when flow through a hood is not required. The hoods are used as part of the normal exhaust from the spaces and, therefore, contain no isolation provisions.

One of each of the two control building exhaust fans and access control exhaust fans runs continuously during normal plant operations. The motor-operated discharge isolation dampers (one associated with each control building exhaust fan) operate in conjunction with their corresponding fans. Automatic back-draft dampers (one associated with each access control exhaust fan) operate in conjunction with their corresponding fans.

The control building exhaust system serves to remove the hydrogen generated by the batteries during normal plant operation. The quantity of air exhausted from each of the battery rooms is well in excess of that which was calculated as necessary to maintain the concentration of hydrogen in the rooms, under the worst conditions, below the flammability limit.

A differential pressure indicator controller, located across the access control filter adsorber unit, modulates a damper downstream of the filter train to maintain a constant system resistance as the particulate filters load up. This control arrangement will assure a constant system flow.

Each charcoal adsorber is monitored for charcoal bed temperature. Should the bed temperature approach 200°F, an alarm would sound in the control room via the plant computer to alert the operators of excessive bed heating. Subsequently, should the bed temperature continue to rise, conditions of 300°F and then 400°F will be alarmed in the control room via the plant computer. Each particulate filter bank is provided with differential pressure transmitters wired to the plant computer which will alarm excessive pressure drops.

The access control air-conditioning system operates in a continuous recirculation mode to provide supplemental cooling or heating of the nonvital equipment areas of the electrical and mechanical equipment room and the first aid room, the RP ALARA Office/ Dosimetry Issue & RP work space rooms, and the Pre-Access area.

The system cooling mode of operation is controlled by a temperature controller which senses return air (space) temperature and functions to maintain the spaces at 76°F. If the temperature falls below 74°F, no cooling is provided. If the temperature falls below 65°F, the heating mode is initiated.

The system heating mode is controlled by a temperature controller located in the unit return air ductwork. This controller energizes the electric duct heater, as necessary, to maintain the return air (space) temperature at 65°F.

Additional heating of the two mechanical equipment rooms is provided by an electric duct heater in the branches serving those spaces. These heaters are each sized for the specific room served and are thermostatically controlled to maintain the space design temperature requirements of 60°F or above.

The control room air-conditioning system operates in a continuous recirculation mode to maintain the control room at or below a temperature of 78°F. The amount of cooling provided by the self-contained refrigeration system is self-regulating and, therefore, automatically compensates for changes in the control room heat load.

Heating, if required, is provided by an electric duct heater. This heater is thermostatically controlled to maintain the space above 72°F. The heater serves no safety function.

The Class 1E electrical equipment air-conditioning system is operated in a continuous recirculation mode to maintain the ESF switchgear room, the battery rooms, and the dc switchgear rooms at or below a temperature of 90°F. The temperatures in these rooms may increase to a maximum of 104°F, under design basis accident (DBA) conditions. The amount of cooling provided by the self-contained refrigeration system is self-regulating and, therefore, automatically compensates itself for changes in the room heat loads.

The counting room cooling coil, counting room backup cooling coil, counting room fan-coil unit and filter unit operate in a continuous recirculation mode to provide the necessary cooling, filtration, and humidity control of the counting room atmosphere to maintain a suitable ambience for the electronic equipment and personnel in the room.

During a normal plant operation the amount of cooling provided by the counting room fan coil unit is controlled by a temperature controller located in the return air duct to the unit. The temperature controller functions to modulate the flow of chilled water to the coil so as to maintain the space temperature and thus return air temperature at 74°F. Additional cooling, if required, can be provided by the counting room cooling coil. Operation of this coil is initiated manually from the counting room by means of a handswitch.

During system outages of the chilled water system the amount of cooling provided by the counting room backup cooling coil is controlled by a temperature controller located in the counting room so as to maintain the space temperature at 74°F.

A moisture switch, located in the counting room fan-coil unit return air duct, senses the relative humidity of the return air and operates the humidifier, as required, to maintain the space relative humidity between 40 and 60 percent.

A HEPA and prefilter filter unit are provided upstream of the fan coil unit to minimize the airborne particulates in the space.

The control building supply air unit intake, the control building exhaust system, control room pressurization, and the access control exhaust system contain dampers capable of withstanding the effects of extreme wind or tornado conditions (3 psi total at a rate of 2 psi/second per Regulatory Guide 1.76). These dampers close with a tornado or high winds. The dampers located in the exhaust systems are spring loaded to prevent closure during normal system operations.

Based on the outside air design conditions, design space heat loads and operation of the control building HVAC systems, as described above, no area of the control building (except for the Decon sink area, the Laundry/Respro Decon area, and the shower areas of the access control area) will exceed a relative humidity of 70 percent.

EMERGENCY OPERATION - Located in the control building supply system ductwork, upstream of the control room, are redundant radiation monitors, redundant carbon monoxide/carbon dioxide monitors, and a smoke detector. These monitors sense

contaminants in the influent and alarm in the control room when limits are exceeded. The high radiation monitors initiate isolation of the control building normal supply and exhaust systems. Chlorine monitors are not required for the Callaway plant per Section 2.2.3.1.3 of the Callaway Site Addendum.

The nonsafety-related systems which penetrate the boundary of the control building are provided with automatic isolation capabilities. This isolation consists of two dampers, aligned in a series arrangement and powered from separate 1E sources. The ductwork located between the two isolation dampers is designed to meet seismic Category I requirements. Upon receipt of the control building isolation signal, these dampers close, thus isolating the control building from all other adjacent buildings and outside air.

The control building isolation signal also automatically bypasses portions of the control room air-conditioning system flow through the associated particulate filter charcoal adsorber train for cleanup and initiates operation of the control room pressurization system. The control room pressurization system draws in outside air, processing it through a particulate filter charcoal adsorber train for cleanup. This outside air is diluted with air drawn from the cable spreading rooms and the electrical equipment floor levels and distributed back into those spaces for further dilution. The control room filtration system takes a portion of air from the exhaust side of this system, upstream of the outside air intake, for dilution with portions of the exhaust air from the control room air-conditioning system and processes it through the control room filtration system adsorption train for additional cleanup. This air is then further diluted with the remaining control room air-conditioning system return air, cooled, and supplied to the control room. This process will maintain the control room under a positive pressure of 1/8 inch w.g. (min.). This will assure exfiltration from the control room, thus preventing any unprocessed contaminants from entering the control room. (The control room is classified as Type B, per the requirements of Regulatory Guide 1.78, with an air exchange rate exceeding 0.06 volume per hour.)

If the control room were isolated but unpressurized, the amount of inleakage resulting from a differential pressure of 1/4 inch w.g., caused by temperature, barometric, or wind variations, would be less than 80 cfm. Leakage rates are calculated in accordance with "Conventional Buildings for Reactor Containment," NAA-SR-101000. The primary paths which contribute to this leakage are (1) the gap between the floor and the ceiling and building walls, (2) the joints between the stairway walls and the chase walls and building walls, (3) the doors to the communication corridor, the electrical chases, and the stairway, (4) the door frames, (5) the ductwork, piping, and electrical penetrations, (6) penetration inserts, and (7) the ductwork isolation dampers.

The major contributors to the leakage are the doors, which account for approximately 95 percent of the total leakage. The remaining paths are both individually and collectively insignificant in terms of the total control room leakage.

The control room pressurization system intake louvers are shown on FSAR Figures 1.2-24 (grid H-4) and 1.2-28 (grid E-3). The control room pressurization system

intake is in the west wall of the control building and is located approximately 80 feet below and 80 feet horizontally from the diesel exhaust discharge point. This separation is sufficient to provide significant dilution of the diesel exhaust gases; therefore, operation of the diesel during periods of control room isolation poses no danger to the occupants of the control room.

The control room pressurization system intakes are located approximately 243 feet horizontally and 202 feet below the unit vent discharge point, 339 feet horizontally and 49 feet below the radwaste building vent discharge point, and 185 feet (nearest exhaust vent) to 403 feet (farthest exhaust vent) horizontally and 121 feet below the turbine building exhaust fan discharge points.

Indication of a loss of preferred ac power, a LOCA, or a fuel handling accident will automatically initiate the Class 1E electrical equipment air-conditioning systems if they are not in operation.

During normal plant operations, the battery rooms are purged with fresh air by the control building supply system and the control building exhaust system. This purging maintains the local concentration of hydrogen well below 0.1 volume percent.

During periods of control building isolation associated with a tornado, dilution air is not provided. This isolation can be maintained for approximately 3 days before purging is required to prevent local hydrogen concentration from approaching 2.0 volume percent (the lower flammability limit). This is based on all batteries at full charge throughout the time period.

During periods of control building isolation, following an accident condition, the hydrogen concentration is maintained well below 0.5 volume percent by dilution with air provided by the control room pressurization system.

The ambient temperature in the battery rooms, under normal operation, is between 60°F and 90°F. For design basis accident (DBA) conditions, the room temperatures may increase to a maximum of 104°F.

FIRE OPERATIONS - The operation of the HVAC systems during a fire and the interface between the ventilation systems and the fire protection system (Section 9.5) vary, depending on the type of fire protection and detection systems employed.

In those areas where smoke detectors and automatic sprinklers are employed (upper and lower cable spreading rooms and access control area) or manual fire-fighting is used (control room, dc switchgear and non-vital switchgear rooms, E1.2016), no interface with or automatic isolation of the HVAC system(s) is provided. If it is determined, following receipt of a fire alarm signal in the control room, that it is necessary to isolate the HVAC system(s) serving the alarmed area, then the operator can initiate isolation from the control room.

In those areas where a halon extinguishing system is employed (1E ac switchgear, El. 2,000), the HVAC system(s) serving those areas are interlocked to provide the necessary isolation upon receipt of a halon actuation signal. A halon release in either of the 1E ac switchgear rooms will automatically isolate the portion of the control building exhaust supply air system and the control building exhaust serving that area and stop the associated Class 1E air-conditioning unit.

9.4.1.3 Safety Evaluation

Safety evaluations are numbered to correspond to the safety design bases in Section 9.4.1.1.

SAFETY EVALUATION ONE - The safety-related portions of the control building HVAC systems are located in the control and auxiliary buildings. These buildings are designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other appropriate natural phenomena. Sections 3.3, 3.4, 3.5, 3.7(B), and 3.8 provide the bases for the adequacy of the structural design of these buildings.

SAFETY EVALUATION TWO - The safety-related portions of the control building HVAC systems are designed to remain functional after a safe shutdown earthquake. Sections 3.7(B).2 and 3.9(B) provide the design loading conditions that were considered. Sections 3.5, 3.6, and 9.5.1 provide the hazards analyses to assure that a safe shutdown, as outlined in Section 7.4, can be achieved and maintained.

SAFETY EVALUATION THREE - The system description for the control building HVAC systems shows that complete redundancy is provided and, as indicated by Table 9.4-5, no single failure will compromise the system's safety functions. All vital power can be supplied from either onsite or offsite power systems, as described in Chapter 8.0.

SAFETY EVALUATION FOUR - The control room system, the Class 1E air-conditioning system, and the control building isolation provisions are initially tested with the program given in Chapter 14.0. Periodic inservice functional testing is done in accordance with Section 9.4.1.4.

Section 6.6 provides the ASME Boiler and Pressure Vessel Code, Section XI requirements that are appropriate for the applicable portions of the control room air-conditioning system and the Class 1E electrical equipment system.

SAFETY EVALUATION FIVE - Section 3.2 delineates the quality group classification and seismic category applicable to the safety-related portions of the control building HVAC systems. All the power supplies and control functions necessary for safe function of the control room air-conditioning system, the Class 1E electrical equipment air-conditioning system, and the control building isolation provisions are Class 1E, as described in Chapters 7.0 and 8.0.

SAFETY EVALUATION SIX - Section 9.4.1.2.3 describes the provisions made to assure the isolation of the control room. Section 6.4 evaluates the isolation requirements of Regulatory Guides 1.78 and 1.95.

SAFETY EVALUATION SEVEN - Completely redundant control room air-conditioning systems are provided for the control room. Each system is powered from independent Class 1E power sources, and headered on separate essential service water systems. Operation of these systems, as discussed in Section 9.4.1.2.3, maintain the design conditions specified in Section 3.11(B).

SAFETY EVALUATION EIGHT - Completely redundant Class 1E electrical equipment air-conditioning systems are provided for the Class 1E Switchgear and Battery areas. Each system is powered from independent Class 1E power sources and headered on separate essential service water systems. Operation of this system, as discussed in Section 9.4.1.2.3, maintains the design conditions specified in Section 3.11(B).

9.4.1.4 Tests and Inspections

Preoperational testing is described in Chapter 14.0.

Filters and adsorbers for the access control exhaust system, the control room pressurization system, and the control room filtration system are tested in the manufacturer's shop, after initial installation, and subsequent to each filter or adsorber change. Following installation of the filters and adsorbers for the safety-related filtration units (control room pressurization and control room filtration units), interim tests and inspections will be performed in accordance with the requirements of Regulatory Guide 1.52 and ASMT D3803-1989, as discussed in Table 9.4-2. Following installation of the filters and adsorbers for the nonsafety-related filtration units (access control filtration unit), interim tests and inspections will be performed in accordance with the requirements of Regulatory Guide 1.140, as discussed in Table 9.4-3.

All charcoal adsorbers were originally factory tested in accordance with RDT M-16-1T to exhibit a decontamination efficiency of no less than 99.9 percent for elemental iodine and 98 percent for methyl iodide. Sample charcoal cannisters will be tested for impregnant efficiency in an independent laboratory using radio-methyl iodide tracers. Used activated charcoal adsorber samples are laboratory tested per the protocols of ASTM D3803-1989 for a methyl iodide penetration of less than 2% when tested at 30°C and 70% relative humidity per Technical Specification 5.5.11.c. Inplace testing is performed with a suitable refrigerant, in accordance with the procedures set forth in ANSI N510, to check for bed bypass leakages.

Prefilters will not undergo factory or inplace testing since no credit is taken for removal of particulates.

HEPA filters will be factory tested with DOP aerosol to demonstrate a minimum particulate removal efficiency of no less than 99.97 percent for 0.3 micron particulates.

Inplace leak testing will be carried out with cold polydispersed DOP. Testing will be in accordance with the procedures set forth in ANSI N510.

One of each type of safety-related fan (control room airconditioning system, control room filtration system, control room pressurization system, and Class 1E electrical equipment air-conditioning system) will be tested in accordance with AMCA standards. All other fans will be AMCA rated.

One control room air-conditioning unit and one Class 1E electrical equipment air-conditioning unit will be performance tested by the manufacturer to assure design heat removal capabilities.

Major components are accessible during normal plant operation for inspection, maintenance, and periodic testing.

9.4.1.5 Instrumentation Applications

Indication of fan operational status is provided in the control room.

All fans, except the counting room fan coil unit fan, are operable from the control room.

An indication of the position of all isolation dampers is provided in the control room.

Thermostats, located in the various levels and the ductwork, control space temperatures.

The indication of the amount of filter loading for all filters associated with the essential and nonessential air handlers is provided at each of the air handlers.

Alarms are provided in the control room to indicate high charcoal bed temperatures in the control room filtration, control room pressurization and access control filtration units and high room temperature in the ESF switchgear and dc switchgear rooms.

An alarm is provided in the control room to indicate high hydrogen concentrations in a battery room.

Alarms are provided in the control room to indicate high carbon monoxide/carbon dioxide concentrations, high radiation, and smoke in the control building intake.

All instrumentation provided with the filtration units is as required by Regulatory Guide 1.52 or 1.140, as applicable.

9.4.2 FUEL BUILDING HVAC

The fuel building ventilation system consists of the fuel building supply system which includes the fuel building heating coil, the fuel building supply air unit, and the fuel handling area cooling coil; the emergency exhaust system, including the emergency

exhaust heating coil; the auxiliary/fuel building normal exhaust system; the spent fuel pool cooling pump room coolers; and the unit heaters. Since both the emergency exhaust system and the auxiliary/fuel building normal exhaust system also serve the auxiliary building, their operation in the auxiliary building is discussed in Section 9.4.3.

The fuel building supply system provides conditioned outside air for ventilation and cooling or heating, as required, to all areas of the fuel building. The auxiliary/fuel building normal exhaust system exhausts air from the area above the spent fuel pool during normal operation and provides a means of purging smoke following a postulated fire.

In the event of a fuel handling accident, the emergency exhaust system collects and processes the airborne particulates in the fuel building. In the event of a LOCA, the emergency exhaust system processes the atmosphere of the auxiliary building.

The fuel storage pool cooling pump room coolers provide a suitable ambient temperature for the electric motor drives of the safety-related pumps.

The fuel building unit heaters provide supplemental heating for the fuel building, when required.

9.4.2.1 Design Bases

9.4.2.1.1 Safety Design Bases

The emergency exhaust system, the fuel storage pool cooling pump room coolers, and those portions of the fuel building supply system and the auxiliary/fuel building normal exhaust system which are required to provide isolation of the fuel building are safety related and are required to function following a DBA and to achieve and maintain the plant in a safe shutdown condition.

SAFETY DESIGN BASIS ONE - The emergency exhaust system, the fuel storage pool cooling pump room coolers, and the HVAC penetrations of the fuel building boundaries are protected from the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, and external missiles (GDC-2).

SAFETY DESIGN BASIS TWO - The emergency exhaust system, the fuel storage pool cooling pump room coolers, and the HVAC penetrations of the fuel building boundary remain functional after a SSE and perform their intended function following a postulated hazard, such as a fire, internal missiles, or pipe break (GDC-3 and 4).

SAFETY DESIGN BASIS THREE - The safety functions of the fuel building HVAC systems can be performed, assuming a single active component failure coincident with the loss of offsite power.

SAFETY DESIGN BASIS FOUR - Active components of the fuel storage pool cooling pump room coolers, the emergency exhaust system, and the fuel building HVAC

boundary penetration isolation provisions are capable of being tested during plant operation. Provisions are made to allow for in-service inspection of components at appropriate times, as specified in the ASME Boiler and Pressure Vessel Code, Section XI.

SAFETY DESIGN BASIS FIVE - The emergency exhaust system, the fuel storage pool cooling pump room coolers, and the HVAC penetrations of the fuel building boundaries are designed and fabricated to codes consistent with the quality group classification assigned by Regulatory Guide 1.26 and the seismic category assigned by Regulatory Guide 1.29. The power supply and control functions are in accordance with Regulatory Guide 1.32.

SAFETY DESIGN BASIS SIX - The ability to isolate the HVAC system penetrations of the fuel building boundaries is provided, when required, so that the emergency exhaust system functions are not compromised.

SAFETY DESIGN BASIS SEVEN - Means are provided to assure both the control and monitoring of radioactive releases following a fuel handling accident (GDC-60 and GDC-64). Radiological consequences of a fuel handling accident are evaluated in Chapter 15.0.

SAFETY DESIGN BASIS EIGHT - The fuel storage pool cooling pump rooms' ambient temperature is limited to assure operability of the fuel storage pool cooling pump.

9.4.2.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - The fuel building ventilation system maintains the space temperature between 60 and 104°F during normal and fuel handling operations.

POWER GENERATION DESIGN BASIS TWO - The auxiliary/fuel building normal exhaust system is sized to exhaust slightly more air than is being supplied to inhibit unprocessed exfiltration from the building.

POWER GENERATION DESIGN BASIS THREE - The fuel building ventilation system is designed to maintain the airborne radioactivity levels within the fuel building below the maximum permissible concentrations (MPC), as defined by 10 CFR 20. The exhaust system is designed to meet the requirements of the discharge concentration limits of 10 CFR 20 and the ALARA dose objective of 10 CFR 50, Appendix I.

9.4.2.2 System Description

9.4.2.2.1 General Description

The fuel building ventilation system is designed to provide fresh air, heated or cooled, as required, for the fuel building. The fuel building and auxiliary building share common

ventilation exhaust systems for normal and emergency operation. The auxiliary/fuel building normal exhaust system is described in Section 9.4.3. The fuel building HVAC systems are shown in Figure 9.4-2.

The emergency exhaust system will collect and process the fuel building atmosphere in the event of a fuel handling accident. During operation of the emergency exhaust system, the nonessential fuel building HVAC air paths are isolated and the building exhausted to assure that fission products and particulate matter are collected and processed. The fuel building intake air system is provided with two motor-operated dampers in a series arrangement.

Indication of high radiation levels in the fuel building will initiate automatic transfer to the emergency exhaust system.

Each fuel storage pool pump room is provided with a local independent room cooler.

During a tornado or extreme wind conditions, the fuel building is vented to equalize pressures.

Based on the source terms provided in Section 11.1 and the dose evaluation provided in Section 11.3, the exhaust system meets the objective of 10 CFR 50, Appendix I, and the limits of 10 CFR 20.

9.4.2.2.2 Component Description

Codes and standards applicable to the fuel building HVAC systems are listed in Tables 3.2-1 and 9.4-6. The emergency exhaust system, fuel storage pool cooling system pump room coolers, and the safety-related HVAC penetrations of the fuel building boundaries are designed and constructed in accordance with codes and standards comparable with quality group C. The spent fuel pool cooling system pump room cooling coils are designed and constructed in accordance with quality group C.

NONESSENTIAL AIR HANDLING UNITS - The fuel building supply air units are the nonessential air handling units in the fuel building. Each unit consists of a chilled-water cooling coil and centrifugal fan with electric motor driver.

SAFETY-RELATED ROOM COOLERS - The only safety-related room coolers located in the fuel building are the fuel storage pool cooling pump room coolers. Each unit consists of an essential service water cooling coil and centrifugal fan with electric motor drives.

SAFETY-RELATED FILTRATION UNITS - The emergency exhaust filter/ adsorber units are located in the fuel building. Each filter train consists of moderate efficiency prefilters, HEPA filters, and charcoal adsorption beds.

SAFETY-RELATED FANS - The emergency exhaust system fans are located in the fuel building. These fans are centrifugal fans with electric motor drivers.

HEATING EQUIPMENT - Heating of the fuel building is provided by a hot-water heating coil located in the fuel building supply air ductwork and by unit heaters located in various areas of the building. Heating of the air to each of the emergency exhaust system filter/ adsorber units is provided by a safety-related electric duct heater. Unit heaters are either hot-water type, consisting of a coil through which hot water passes and an electric motor-driven fan, or electrical-resistance type, consisting of a resistant coil and an electric motor-driven fan.

SUPPLEMENTAL COOLING - Additional cooling is provided, when required, by a chilled-water cooling coil located in the supply air system ductwork to the fuel storage pool area.

ISOLATION DAMPERS - Where a means of system isolation is required, parallel-blade-type dampers are utilized. The type of operator employed is dependent upon the specific design and/or usage requirements.

FLOW CONTROL DAMPERS - Opposed-blade-type dampers are utilized, as necessary, to provide a means of system balancing. In general, these are manually operated. However, some utilize power operators to allow compensation for changes occurring during system operation.

BACKDRAFT DAMPERS - Backdraft dampers are employed, where required, to maintain the proper direction of flow.

TORNADO DAMPERS - Tornado dampers are employed where isolation from the effects of extreme wind or tornado conditions is required. These dampers close with the flow produced by the differential pressure associated with the tornado or high winds.

FIRE DAMPERS - Fire dampers are located in fire barriers, as necessary, to maintain the fire ratings of the barriers. Dampers are the 3-hour-rated curtain type.

9.4.2.2.3 System Operation

The fuel building is served by an outside air supply system which provides fresh outside air, either heated or cooled as required, to all areas of the fuel building. The supply air unit has provisions for operating in a recirculation mode. Additional cooling for the fuel handling area is provided by a cooling coil located in the duct supplying that area.

Within the fuel building, the auxiliary/fuel building normal exhaust system takes suction from the area above the spent fuel pool and mixes that air with the air from the auxiliary building prior to processing it through the auxiliary/fuel building filter adsorber train and discharging it to the unit vent.

The emergency exhaust system collects and processes the fuel building atmosphere in the event of a fuel handling accident. During operation of the emergency exhaust system, the fuel building nonessential HVAC air paths are isolated and the building

exhausted to assure that fission products and particulate matter are collected and processed. The fuel building intake air system is provided with two motor-operated dampers in a series arrangement. Each damper is powered from a separate Class 1E source to assure closure. Transfer from the normal HVAC operations to the emergency HVAC operations occurs automatically upon receipt of a fuel building isolation signal. The emergency exhaust system maintains a minimum negative pressure of 1/4 in. w.g. to assure that all leakage is into the building.

The emergency exhaust system is on standby for an automatic start following receipt of a fuel building isolation signal or a safety injection signal (SIS). The initiation of the LOCA mode of operation (SIS) takes precedence over any other mode of operation.

Each fuel storage pool cooling pump room is provided with a local independent cooling unit. These cooling units utilize essential service water as the heat sink (service water during normal plant operation) and are powered by the same Class 1E power supply as the associated pump to be cooled. Each unit has the capacity to provide 100 percent of the cooling required.

During a tornado or extreme wind conditions, the fuel building will be vented to equalize pressures. Missile protection is provided to prevent a tornado missile from damaging HVAC equipment required during safe shutdown.

Discussed below are the power generation operations and the emergency operations of the fuel building HVAC systems.

The differences between shutdown operations and power operations are few and are, therefore, covered under the power generation operations.

POWER GENERATION OPERATION - Outside air is drawn in by one of the two supply air units, filtered through the particulate filter, conditioned as required, and distributed to the various areas of the fuel building. Depending on the space temperature requirements, the outside air is either heated by the hot-water coil located in the outside air intake or cooled by the supply air unit's chilled-water coil. Each fuel storage pool cooling pump room is provided with a room cooler to maintain the ambient temperature within limits. Space heating is provided by the outside air intake heating coil and supplemented by hot-water and electric unit heaters.

The heating or cooling mode of operation of the outside air intake unit is controlled by the outside air temperature. When the outside air temperature exceeds 78°F, the chilled-water-cooled outside air is supplied to the building. When the outside air temperature is between 78°F and 50°F, outside air is supplied directly into the building. When the outside air temperature is below 50°F, the heating system is operational. These operations are controlled by temperature switches located in the inlet ductwork, upstream of the coils.

When the outside air temperature rises above 78°F, the temperature switch associated with the cooling system activates the supply unit cooling control system. This control system then functions to maintain a constant supply air temperature, by modulating the flow of chilled water to the coil.

During fuel handling operations, the supplementary chilled-water coil located in the supply air duct may be manually actuated. Once actuated, the chilled-water flow to the coil is automatically modulated to limit the ambient temperature in the fuel handling area to 104°F.

When the outside air temperature falls below 50°F, a temperature switch activates the heating coil control system. The heating coil is supplied from a secondary hot-water loop which is, in turn, supplied from the plant heating system. This arrangement is provided to circulate water through the coil to prevent a possible freezeup of the coil.

The heating control system consists of temperature transmitters located in various spaces, which sense the space temperature and transmit a corresponding signal to a single temperature controller. When any of these signals indicates that a space temperature is below 60°F, the temperature controller then modulates the amount of heating accordingly. The temperature controller controls the secondary loop temperature by regulating the amount of hot water which enters the secondary loop of the heating coil.

A temperature switch is provided in the supply air duct downstream of the heating coil. This temperature switch will isolate the supply air intake and trip the supply fan, should the supply air temperature drop below 40°F, to protect the coils from freezing.

The fuel building supply air system intake is in the side of the west wall of the fuel building, and is located approximately 70 feet below and 165 feet horizontally from the diesel exhaust discharge point. This separation is sufficient to provide significant dilution of the diesel exhaust gases; therefore, operation of the diesel during normal plant operations will result in no significant ingestion of exhaust gases into the fuel building.

Supplemental heating is provided by unit heaters located throughout the building. Each unit heater is sized for its location, and each is thermostatically controlled to maintain the space design requirements of 60°F or above.

The auxiliary/fuel building normal exhaust system components are located in the auxiliary building and are described in Section 9.4.3. All normal exhaust from the fuel building is through the auxiliary/fuel building normal exhaust system.

The auxiliary/fuel building normal exhaust system and/or the emergency exhaust system provide a means of purging smoke following a postulated fire.

The operation of the supply air units is interlocked with the operation of the auxiliary/fuel building normal exhaust fans. A supply air unit will operate in the supply mode only if an

auxiliary/fuel building normal exhaust fan is operating at fast speed. When a normal exhaust fan is operating at slow speed, the supply air unit will operate only if in the recirculation mode of operation.

The fuel building intake air isolation system consists of two dampers in a series arrangement, each powered by a separate Class 1E source. The dampers are designed to close automatically upon a high radiation indication within the fuel building.

EMERGENCY OPERATIONS - Actuation of the emergency mode of operation is initiated either manually by operator action or automatically upon detection of high radiation levels in the fuel building.

Actuation of the fuel building ventilation isolation signal (FBVIS) isolates the outside air intake system, trips the supply air handling units, and closes the corresponding damper in the normal exhaust ductwork to the auxiliary building in order to isolate the fuel building. Refer to Section 7.3.3.

In the event of a LOCA, the SIS trips off the fuel building supply fan and closes the dampers in the normal exhaust system to isolate the fuel building exhaust ductwork from the auxiliary building. The SIS concurrently energizes the emergency exhaust fan and opens the corresponding damper in the emergency ductwork from the auxiliary building so that all exhaust from it is processed through the fuel building emergency exhaust filter train. Under this mode, all nonessential fuel building HVAC is out of service.

Each charcoal adsorber train is monitored for charcoal bed temperature. Should the bed temperature approach 200°F, an alarm would sound in the control room to alert the operators of excessive bed heating. To prevent backflow through the system, upstream isolation is provided by a backdraft damper located at the inlet to the filter train. Each particulate filter bank is provided with differential pressure transmitters wired to the plant computer which will alarm excessive pressure drops.

The emergency exhaust system is provided with electric heaters which start automatically with it's associated emergency exhaust fan, to maintain the relative humidity of the air entering the charcoal filters below 70 percent.

The fuel storage pool cooling pump room coolers are activated when their associated pump starts. Each pump room cooler is full capacity, utilizes service water (normal operations) or essential service water (accident operations) as the cooling medium, and is powered from the same Class 1E source as the associated spent fuel pool cooling pump. Each pump room cooler is located in its respective pump room and operates in a complete recirculation mode. Each pump room is monitored for high space temperature; which will be alarmed in the control room via the plant computer. Fresh air for ventilation is provided during normal plant operation by the fuel building supply system.

9.4.2.3 Safety Evaluation

Safety evaluations are numbered to correspond to the safety design bases in Section 9.4.2.1.

SAFETY EVALUATION ONE - The safety-related portions of the fuel building HVAC systems are located in the fuel building and the auxiliary building. These buildings are designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other appropriate natural phenomena. Sections 3.3, 3.4, 3.5, 3.7(B), and 3.8 provide the bases for the adequacy of the structural design of these buildings.

SAFETY EVALUATION TWO - The safety-related portions of the fuel building HVAC systems are designed to remain functional after a safe shutdown earthquake. Sections 3.7(B).2 and 3.9(B) provide the design loading conditions that were considered. Sections 3.5, 3.6, and 9.5.1 provide the hazards analyses to assure that a safe shutdown, as outlined in Section 7.4, can be achieved and maintained.

SAFETY EVALUATION THREE - Complete redundancy is provided and, as indicated by Table 9.4-7, no single failure will compromise the system's safety functions. All vital power can be supplied from either onsite or offsite power systems, as described in Chapter 8.0.

SAFETY EVALUATION FOUR - The fuel storage pool cooling pump room coolers, the emergency exhaust system, and the fuel building HVAC boundary penetration isolation provisions are initially tested with the program given in Chapter 14.0. Periodic inservice functional testing is done in accordance with Section 9.4.2.4.

Section 6.6 provides the ASME Boiler and Pressure Vessel Code, Section XI requirements that are appropriate for the spent fuel pool cooling pump room coolers.

SAFETY EVALUATION FIVE - Section 3.2 delineates the quality group classification and seismic category applicable to the safety-related portion of this system and supporting system. All the power supplies and control function necessary for safe function of the fuel storage pool cooling pump room coolers, emergency exhaust system, and the fuel building HVAC boundary penetration isolation provisions are Class 1E, as described in Chapters 7.0 and 8.0.

SAFETY EVALUATION SIX - Section 9.4.2.2.3 describes the provisions made to assure the isolation of the auxiliary building following a DBA.

SAFETY EVALUATION SEVEN - The emergency exhaust system maintains a negative pressure of no less than 1/4 in. w.g. in the fuel building to prevent unprocessed exfiltration following a fuel handling accident which releases radioactivity. The emergency exhaust system is monitored for radioactivity downstream of the filter adsorber unit prior to release to the site. The filter adsorber unit limits the radiological consequences of a fuel handling accident to less than 10 CFR 100 limits.

SAFETY EVALUATION EIGHT - Room coolers are installed in each fuel storage pool cooling pump room and are designed to maintain these rooms below 122°F (50°C), based on maximum heat load within the room.

9.4.2.4 Tests and Inspections

Preoperational testing is described in Chapter 14.0.

Filters and adsorbers for the emergency exhaust system are tested in the manufacturer's shop, after initial installation and subsequent to each filter or adsorber change. After installation, interim tests and inspections will be performed after every 720 hours of operation and once per 18 months in accordance with the requirements of Regulatory Guide 1.52 and ASTM D3803-1989 as discussed in Table 9.4-2, to detect any deterioration of components that may develop under service or standby conditions.

Prefilters will not undergo factory or inplace testing since no credit is taken for removal of particulates in meeting permissible dose rates.

HEPA filters will be factory tested with monodispersed DOP aerosol to demonstrate a minimum particulate removal efficiency of no less than 99.97 percent for 0.3 micron particulates. Inplace leak testing will be carried out with polydisperse DOP. Testing will be in accordance with procedures set forth in ANSI N510.

Charcoal adsorbers will be qualified per the discussions in Table 9.4-2 and were originally factory tested in accordance with RDT M-16-IT to exhibit a decontamination efficiency of no less than 99.9 percent for elemental iodine and 98 percent for methyl iodide. Sample charcoal canisters will be tested for efficiency in an independent laboratory, using radiomethyl iodide tracers. Used activated charcoal adsorber samples are laboratory tested per the protocols of ASTM D3803-1989 for a methyl iodide penetration of less than 2% when tested at 30°C and 70% relative humidity per Technical Specification 5.5.11.c. Inplace testing is performed with a suitable refrigerant, in accordance with the procedures set forth in ANSI N510, to check for bed bypass leakages.

All systems constituting the fuel building ventilation system will undergo preoperational testing prior to plant start-up.

One fan from each of the emergency exhaust fans and spent fuel pool cooling pump room cooler fans will be tested in accordance with AMCA standards. All other fans will be AMCA rated.

Major components are accessible during normal plant operation for inspection, maintenance, and periodic testing.

9.4.2.5 Instrumentation Applications

Indication of the operational status of all fuel building HVAC fans is provided in the control room.

All fans, except the fuel storage pool cooling pump room cooler fans, are operable from the control room.

An indication of the position of all isolation dampers is provided in the control room.

Thermostats, located in various areas of the fuel building and in the HVAC ductwork, control space temperatures.

The amount of filter loading for the supply air unit intake filter is indicated at the supply unit.

Indication of the levels of gaseous particulate and iodine radioactivity being exhausted from the fuel building during all modes of operation is available in the control room.

All instrumentation provided with the emergency exhaust filter/adsorber unit is as required by Regulatory Guide 1.52.

A high temperature computer alarm for each of the fuel storage pool cooling pump rooms is provided in the control room.

9.4.3 AUXILIARY BUILDING

The auxiliary building ventilation system consists of the auxiliary building supply system, the auxiliary/fuel building normal exhaust system, the emergency exhaust system, the main steam tunnel supply system, the main steam tunnel exhaust system, and the auxiliary building transfer fan and the laundry dryer supply and exhaust system. Local fan coil units serve the electrical equipment room, the component cooling water pump room, the ground floor corridor, the laundry decontamination facility, the normal charging pump room, and the basement corridor. Local room coolers serve the safety injection pump rooms, the component cooling water pump rooms, the RHR pump rooms, the charging pump rooms, the containment spray pump rooms, the auxiliary feedwater (motor-driven) pump rooms, and the electrical penetration rooms.

Since both the auxiliary/fuel building normal exhaust system and the emergency exhaust system also serve the fuel building, their operation in the fuel building is described in Section 9.4.2. All modes of operation discussed in this section are applicable to the auxiliary building only.

The auxiliary building supply system and the main steam tunnel supply system function to provide conditioned outside air for ventilation and cooling or heating, as required, to each level of the auxiliary building except for the 1988 pipe chase elevation. During

normal operations, the auxiliary/fuel building normal exhaust system and the main steam tunnel exhaust system operate to provide the required exhaust from the building. However, due to flow imbalances in the main steam tunnel, not all supplied air is exhausted via the main steam tunnel exhaust system. These systems also provide a means of purging smoke following a postulated fire.

During periods when the laundry dryers are in use, the dryers intake makeup air from outside the laundry decontamination facility and exhaust the air back outside the building. The dryer air supply and exhaust system does not interface with any other HVAC system and does not use any air from within the building

Following a LOCA, the emergency exhaust system serves to collect and process airborne particulates in the auxiliary building and exhausts the air purged from the containment via the containment hydrogen control system.

The fan coil units serve to provide supplemental cooling of the auxiliary building, as required.

The pump room coolers provide a suitable ambient environment for the electric motor drivers for the safety-related pumps.

The penetration room coolers provide a suitable atmosphere for the safety-related electrical equipment located in the electrical penetration rooms.

The auxiliary building transfer fan functions to supply air from the auxiliary building basement corridor to the radwaste tunnel.

The auxiliary building unit heaters provide supplemental heating to the auxiliary building, when required.

9.4.3.1 Design Bases

9.4.3.1.1 Safety Design Bases

The pump room coolers, the penetration room coolers, the emergency exhaust system, and those portions of the auxiliary building and the main steam tunnel supply systems and the auxiliary/fuel building normal exhaust and main steam enclosure building exhaust systems which are required to provide isolation of the auxiliary building are safety related and are required to function following a DBA and to achieve and maintain the plant in a safe shutdown condition.

SAFETY DESIGN BASIS ONE - The pump room coolers, the penetration room coolers, the emergency exhaust system, and the auxiliary building isolation provisions are protected from the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, and external missiles (GDC-2).

SAFETY DESIGN BASIS TWO - The pump room coolers, the penetration room coolers, the emergency exhaust system, and the isolation provisions for the auxiliary building remain functional after a safe shutdown earthquake and perform their intended function following a postulated hazard, such as a fire, internal missiles, or pipe break (GDC-3 and 4).

SAFETY DESIGN BASIS THREE - The safety functions of the auxiliary building HVAC systems can be performed, assuming a single active component failure coincident with the loss of offsite power.

SAFETY DESIGN BASIS FOUR - Active components of the auxiliary building safety-related HVAC systems are capable of being tested during plant operation. Provisions are made to allow for inservice inspection of components at appropriate times specified in the ASME Boiler and Pressure Vessel Code, Section XI.

SAFETY DESIGN BASIS FIVE - The pump room coolers, the penetration room coolers, the emergency exhaust system, and the safety-related auxiliary building isolation provisions are consistent with the quality group classification assigned by Regulatory Guide 1.26 and with the seismic category assigned by Regulatory Guide 1.29. The power supply and control functions must be in accordance with Regulatory Guide 1.32.

SAFETY DESIGN BASIS SIX - The capability to isolate both the safety- and nonsafety-related HVAC system penetrations of the auxiliary building boundary is provided so that the safety-related HVAC systems' functions are not compromised.

SAFETY DESIGN BASIS SEVEN - Means are provided to assure both the control and monitoring of gaseous radioactive releases to the site following a LOCA. The radiological consequences are evaluated in Section 15.0.

SAFETY DESIGN BASIS EIGHT - The ESF pump room coolers limit the ESF pump room ambient temperature to assure operability of the ESF pump.

9.4.3.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - The auxiliary building supply system provides conditioned outside air to maintain the ground floor level of the auxiliary building at or below 104°F (except as noted in Tables 3.11(B)-1 and 3.11(B)-2 for pump rooms with pumps in operation. The auxiliary building supply system also provides supplemental cooling for each of the other floor levels of the auxiliary building. The auxiliary building supply system provides fresh air ventilation at a rate of 0.1 cfm/ft^2 of floor area or greater.

POWER GENERATION DESIGN BASIS TWO - The main steam tunnel supply and exhaust systems limit the temperature to a maximum of 120°F and a minimum of 50°F and provide fresh air ventilation.

POWER GENERATION DESIGN BASIS THREE - The auxiliary/fuel building normal exhaust system exhausts slightly more air than is being supplied, to inhibit exfiltration of the air from the auxiliary building. The main steam tunnel exhaust system may exhaust less air than is being supplied to assure adequate cooling.

POWER GENERATION DESIGN BASIS FOUR - The auxiliary building ventilation system maintains the auxiliary building sample room, and the laundry decontamination facility at a suitable environment for equipment and personnel. All other areas of the auxiliary building are maintained between 60°F and 104°F, except as discussed in Tables 3.11(B)-1 and 3.11(B)-2. The boric acid storage tank areas, the pipe chase containing the 4 weight percent boric acid piping which runs between the tanks and the boric acid filters, and the boric acid filter valve gallery are maintained at a minimum of 75°F to prevent crystallization of the 7000 to 7700 ppm boron solution in the lines.

POWER GENERATION DESIGN BASIS FIVE - The auxiliary building air flow patterns are from levels of lower contamination potential to levels of higher contamination potential.

POWER GENERATION DESIGN BASIS SIX - The dryer air supply and exhaust system is a closed system that is not connected to the rest of the Auxiliary Building HVAC system to prevent it from having any effect on the flow balance for normal building ventilation.

POWER GENERATION DESIGN BASIS EIGHT - The ventilation exhaust system is designed to meet the requirements of the discharge concentration limits of 10 CFR 20 and the ALARA dose objective of 10 CFR 50, Appendix I. The auxiliary/fuel building normal exhaust system filter adsorber unit complies with Regulatory Guide 1.140, to the extent discussed in Table 9.4-3.

9.4.3.2 System Description

9.4.3.2.1 General Description

The auxiliary building HVAC system is shown in Figure 9.4-3.

The auxiliary building is served by an outside air supply system which provides fresh outside air, either heated or cooled as required, to all levels of the auxiliary building. Local fan coil units serve the basement corridor area, the normal charging pump room, the ground floor corridor, the laundry decontamination facility, the component cooling water pump room, and the electrical equipment room areas of the auxiliary building. Local cooling units are provided to minimize ductwork requirements.

The Ram Storage Building maintains a negative air pressure by exhausting air from the building via the Laundry Decon Facility to the unit vent. The make up air enters via infiltration around the outside doors. The Ram Storage Building utilizes two fan coil units in recirculation for cooling and two unit heaters in recirculation for heating when required.

The main steam tunnel is served by a unit which employs outside air for cooling. A hot-water heating coil and chilled water cooling coil are provided in the unit to supply the required heating and cooling.

The auxiliary/fuel building normal exhaust system takes suction from the areas of greater contamination potential of the auxiliary building and RAM Storage Building, mixes this exhaust air with the exhaust air from the fuel building, and processes the exhaust air through a charcoal adsorber train prior to discharge through the unit vent. Based on the source terms provided in Section 11.1 and the dose evaluation provided in Section 11.3, the exhaust system meets the objective of 10 CFR 50, Appendix I, and the limits of 10 CFR 20.

The main tunnel exhaust system takes suction from all levels of the main steam tunnel and a substantial portion of the supplied air discharges directly to the unit vent. Excess supplied air exhausts from the main steam tunnel through the exhaust louver near the top of the enclosure and via missile shield spacing, floor drains an annular spacing around the main steam safety valves. This excess air need not be radiologically monitored since the potential for release and resultant consequences are inconsequential.

Both the auxiliary/fuel building normal exhaust system and the main steam tunnel exhaust system are monitored for activity, in accordance with the requirements of Regulatory Guide 1.21.

The emergency exhaust system serves the auxiliary building only following a LOCA to assure that all ECCS leakage to the auxiliary building atmosphere and the containment air purged via the hydrogen purge system are processed. All ductwork which is not required for operation of the emergency exhaust system and penetrates the auxiliary building boundary is automatically isolated. These nonessential systems are provided with two motor-operated dampers in a series arrangement at the boundary penetrations. These will close automatically following receipt of an SIS. The emergency exhaust system will maintain a negative pressure of 1/4 in. w.g. to assure that all leakage is into the building.

Each area except the main steam tunnel containing safety-related equipment that is heat sensitive is provided with a local independent cooling unit. These cooling units utilize essential service water as the heat sink and are powered by the same Class 1E supply as the associated equipment to be cooled. The main steam tunnel air unit utilizes a chilled-water cooling coil.

The laundry dryers obtain fresh supply air from outside the laundry decontamination facility and is heated by steam coils on each dryer. The dryer exhaust is filtered and monitored before it is discharged back outside the laundry decontamination facility. This is a closed system and has no effect on air volumes into or out of the laundry decontamination facility's rooms.

Supplemental heating is provided by unit heaters located throughout the building.

The auxiliary building transfer fan transfers air from the auxiliary building to the radwaste tunnel.

An evaluation of the effects of the postulated inability to maintain preferred air flow patterns in the auxiliary building is summarized below:

a. Loss of Auxiliary Building Supply System

The auxiliary/fuel building normal exhaust system has the capability of operating at a reduced flow following the postulated loss of the supply system. Depending on physical resistance to building infiltration and fan characteristics, both exhaust fans may be operated in a parallel arrangement to maintain approximate design flow rates.

The ductwork distribution system is designed to supply directly to the clean areas, such as corridors, and exhaust from the potentially contaminated areas, such as equipment compartments. With the postulated loss of supply air, the exhaust pattern from the potentially contaminated areas will be maintained. The source of makeup air will be building infiltration which will flow toward the potentially contaminated areas. Therefore, the effect of this event is negligible.

b. Loss of Auxiliary/Fuel Building Normal Exhaust System

The auxiliary/fuel building normal exhaust system is provided with redundant, full-capacity fans. However, assuming a loss of the exhaust air flow, the supply system will be automatically shut down to prevent building pressurization. The supply fan is interlocked with the exhaust system so that the exhaust system must be operating before the supply system can be started or operated.

Therefore, a postulated loss of the exhaust system will result in a complete loss of direct outside air movement within the auxiliary building. Natural air flow patterns may be established, depending on thermal gradients and the flow paths existing within and across the auxiliary building. Assuming uniform mixing of the auxiliary building atmosphere as the most conservative case, there would be negligible effect in relation to operator exposure if the ventilation system is returned to service within several hours. For a more prolonged outage, actions will be taken as necessary to provide several days to restore the ventilation system to service without exceeding DAC levels per 10CFR20, excluding noble gas and short lived particulates, within the auxiliary building.

The loss of normal ventilation will have no impact on those areas with safety-related equipment.

The equipment room housing the auxiliary building exhaust components is located on the operating floor which houses radioactively clean components. In addition, the exhaust fans are reliable belt-driven centrifugal fans.

9.4.3.2.2 Component Description

Design data for major components of the auxiliary building HVAC systems are presented in Table 9.4-8. Codes and standards applicable to the auxiliary building HVAC systems are listed in Table 3.2-1. The pump room coolers, penetration room coolers, emergency exhaust system, and the safety-related penetrations of the auxiliary building boundaries are designed and constructed in accordance with codes and standards comparable with quality group C. The pump room cooler cooling coils and the penetration room cooler cooling coils are designed and constructed in accordance with quality group C.

NONESSENTIAL AIR HANDLING UNITS - Listed and described below are those nonessential air handling units which make up a part of the auxiliary building HVAC system.

The auxiliary building supply air unit consists of particulate filters, hot-water heating coil, chilled-water cooling coil, centrifugal fan, and electric motor driver.

The main steam tunnel supply air unit consists of particulate filters, hot-water coil, chilled water cooling coil, centrifugal fan, and electric motor driver.

The electrical equipment fan coil units, the component cooling water pump room fan coil unit, the ground floor fan coil unit, the laundry decontamination facility fan coil unit, the normal charging pump room fan coil unit, and the basement corridor fan coil unit each consist of particulate filters, chilled-water cooling coil, centrifugal fan, and electric motor.

The laundry dryer air supply and exhaust system consist of power operated dampers, HEPA filters, centrifugal fan with electric motor driver and a radiation monitor. All are controlled by a PLC, which monitors and controls dryer operation, damper operation, exhaust fan, and the radiation monitor.

SAFETY-RELATED ROOM COOLERS - Those room coolers which provide safety-related cooling are described below.

The SI pump room coolers, the RHR pump room coolers, the component cooling water pump room coolers, the ECCS centrifugal charging pump room coolers, the containment spray pump room coolers, the auxiliary feedwater pump room coolers, and the penetration room coolers each consist of coils utilizing essential service water as the

cooling medium, centrifugal fans, and electric motor drivers. Units which normally operate are provided with particulate filters.

NONESSENTIAL FILTER UNITS - The auxiliary building HVAC systems contain four nonessential filter units. One is the auxiliary/fuel building normal exhaust filter adsorber unit, which consist of moderate efficiency prefilters. HEPA filters, and charcoal adsorption beds. The other three, the laundry decontamination facility dryer exhaust filter unit, the laundry sorting/tool cleaning stations filter unit, and the trash sorting station filter unit, each consist of a prefilter and a HEPA filter.

SAFETY-RELATED FILTER UNITS - The auxiliary building HVAC systems contain no safety-related filter units. The emergency exhaust filter adsorber units are described in Section 9.4.2.2.2.

NONESSENTIAL FANS - There are seven nonessential fans in the auxiliary building HVAC system. The auxiliary/fuel building normal exhaust fans, the laundry decontamination facility dryer exhaust fan, the laundry sorting/tool cleaning exhaust fan, the trash sorting exhaust fan, and the main steam tunnel exhaust fans are centrifugal fans with electric motor drivers. The tunnel transfer fan is a propeller fan with an electric motor driver. The sample panel exhaust booster fan is an axial fan driven by an electric motor.

SAFETY-RELATED FANS - The auxiliary building HVAC systems contain no safety-related fans. The emergency exhaust system fans are described in Section 9.4.2.2.2.

SUPPLEMENTAL HEATING - Supplemental heating is supplied by electric duct heaters and electric and hot-water unit heaters.

The hot-water and electric unit heaters are located throughout the auxiliary building to provide supplemental heating. Each unit heater consists of a coil and a fan with an electric motor driver.

FIRE DAMPERS - Fire dampers are located between fire barriers, as necessary, to maintain the fire ratings of the barriers. Dampers are the 3-hour-rated curtain type.

ISOLATION DAMPERS - Where a means of system isolation is required, parallel-blade-type dampers are utilized. The type of operator employed is dependent upon the specific design and/or usage requirements.

FLOW CONTROL DAMPERS - Opposed-blade-type dampers are utilized, as necessary, to provide a means of system balancing. In general, these are manually operated. However, some utilize power operators to allow compensation for changes occurring during system operation.

BACKDRAFT DAMPERS - Backdraft dampers are employed, where required, to maintain the proper direction of flow.

TORNADO DAMPERS - Tornado dampers are employed where isolation from the effects of extreme wind or tornado conditions is required. These dampers close with the flow produced by the differential pressure associated with the tornado or high winds.

9.4.3.2.3 System Operation

GENERAL - The auxiliary building is served by two outside air supply units, one which serves all areas of the auxiliary building, except the main steam tunnel, and one which serves only the main steam tunnel.

Recirculation units (both essential and nonessential) are utilized throughout the building to supplement the outside air units' cooling (nonessential), provide cooling for the safety-related equipment, and minimize ductwork requirements.

Three exhaust systems serve the auxiliary building. The main steam tunnel exhaust system takes suction from the main steam tunnel and discharges to the atmosphere through the unit vent. The auxiliary/fuel building normal exhaust system takes suction from the potentially contaminated areas of the auxiliary building and Ram Storage Building, and processes it through a charcoal adsorber train prior to release through the unit vent. The emergency exhaust system exhausts from the auxiliary building following a LOCA and processes the air through a charcoal adsorber train prior to releasing it through the unit vent.

The laundry dryer air supply and exhaust system draws fresh air from outside the laundry decontamination facility. This air is then heated by steam coils in the dryers and used to dry the laundry. The air is then discharged through a filter system to remove possible radioactive contamination and then exhausted outside the laundry decontamination facility.

The tunnel transfer fan transfers air from the auxiliary building to the clean side of the radwaste tunnel. This air is then exhausted through the hot side of the tunnel by the auxiliary/fuel building normal exhaust.

Cooling water for the nonessential air handlers is supplied by the central chilled water system (Section 9.4.10), and cooling water for the safety-related room coolers is supplied by the essential service water system (Section 9.2.1). Hot water for the supply air unit and the unit heaters is supplied by the plant heating system (Section 9.4.9).

Discussed below are the power generation operations and emergency operations of the auxiliary building HVAC systems. Shutdown operations are identical to the power generation operations.

POWER GENERATION OPERATION - Operation of the auxiliary building supply system, the auxiliary/fuel building normal exhaust system, the main steam tunnel supply system, and the main steam tunnel exhaust system is initiated manually from the control room. These systems operate continuously during normal plant operations.

The auxiliary building supply air unit draws in outside air, filters it through low efficiency particulate filters, either cooling with a chilled-water coil or heating with a hot-water coil, and distributes the conditioned air to the separate floors of the auxiliary building. In addition to the outside air cooling, local cooling is provided by supplemental fan-coil units which utilize chilled water coils for cooling. Space heating is provided by the outside air unit and unit heaters.

The main steam tunnel supply system utilizes outside air as the cooling medium. The supply air unit draws in outside air, filters it through low efficiency filters, tempering it if required, and distributing it throughout the building.

The following description of the operation of an outside air unit is, in general, applicable to both the auxiliary building supply air unit and the main steam tunnel supply air unit. However, those portions which apply to the cooling mode are not applicable to the main steam enclosure building.

The heating or cooling mode of operation of the outside air supply unit is a function of the outside air temperature only. When the outside air temperature exceeds 65°F, conditioned outside air is supplied to the building. When the outside air temperature is between 65 and 50°F, unconditioned outside air is supplied to the building, and when the outside air temperature is below 50°F, the heating system is operational. These operations are controlled by temperature switches, one associated with each coil, located in the ductwork upstream of the coils which sense the outside air temperature and function accordingly.

When the outside air temperature rises above 65°F, the temperature switch associated with the cooling system activates the supply unit cooling control system. This control system then functions to maintain a constant supply air temperature of 60°F by modulating the flow of chilled water to the coil.

While the outside air temperature is between 65 and 50°F, the supply unit continues to supply unconditioned air to the building.

When the outside air temperature falls below 50°F, the temperature switch associated with the heating coil activates the supply unit heating control system. The supply unit heating coil is supplied from a secondary hot-water loop. This arrangement is provided to prevent the possible freezeup of the coil when the outside air temperature falls below 32°F.

The supply unit heating control system consists of temperature transmitters, located on 1974, 2000, and 2026 levels, which sense the corridor temperature and transmit a

corresponding signal to a single temperature controller. When any one of these signals indicates that a corridor temperature is below 60°F, the temperature controller then increases the amount of heating from the supply unit heating coil to maintain a minimum of 60°F on all levels. The temperature controller controls the secondary loop temperature by regulating the amount of hot water which enters the secondary loop of the heating coil.

A temperature switch is provided in the supply air duct downstream of the outside air unit. This temperature switch will trip the supply unit, should the supply temperature drop below 40°F, to protect the coils from freezing.

The auxiliary building supply air system and the main steam enclosure supply air system intakes are in a penthouse atop the auxiliary building, which is located approximately 15 feet below and 135 feet horizontally from the diesel exhaust discharge point. This separation is sufficient to provide significant dilution of the diesel exhaust gases; therefore, operation of the diesel during normal plant operations will result in no ingestion of exhaust gases into the auxiliary building.

The basement corridor fan coil unit, the normal charging pump room fan coil unit, the laundry decontamination facility fan coil unit, the ground floor fan coil unit, the component cooling water pump room fan coil unit, and the electrical equipment room fan coil unit operate to provide supplemental cooling of the auxiliary building. The operation of these units is controlled by a temperature switch located in the respective room and/or area served. This switch activates the unit fan when the room or area temperature exceeds the design limits. The basement corridor fan coil unit, the normal charging pump room cooler, the ground floor corridor fan coil unit, and the component cooling water pump room fan coil unit temperature switches are set to initiate operation of the unit when the room temperature exceeds 90°F and to stop the unit before the room temperature falls below 80°F. The electrical equipment room fan coil units each have a temperature switch set to initiate operation before the room temperature exceeds 80°F.

Supplemental heating is provided by unit heaters located in the basement corridor, the laundry decontamination facility, the intermediate floor corridor, the auxiliary building operating floor HVAC equipment room, the containment personnel access area, the boric acid storage tanks area, and pipe chase. Each heater is sized for its specific location and is thermostatically controlled to maintain the space design temperature requirements of 60°F or above. The boric acid storage tank area, pipe chase, unit heaters maintain a space temperature of 75°F or above to prevent crystallization of the minimum 7000 ppm boric acid in the tanks and/or lines.

The auxiliary building supply air unit intake, the auxiliary/fuel building normal exhaust system discharge and the auxiliary/fuel building normal exhaust system, the emergency exhaust system, the auxiliary building transfer fan, and the laundry decontamination facility fan coil unit, exhaust line penetrations of the auxiliary building boundaries contain tornado dampers capable of withstanding the effects of extreme wind or tornado conditions (3 psi total at a rate of 2 psi per second per Regulatory Guide 1.76). These

dampers close with the flow produced by the differential pressure associated with the tornado or high winds. The dampers located in those systems whose normal flow is in the same direction as would be the flow produced by the differential pressure are spring loaded to prevent closure during normal system operations. Missile barriers are provided externally to the isolation system to prevent propagation of a tornado missile.

Each pump room is provided with an individual cooler which provides cooling for the associated pump area. Each penetration room cooler serves one electrical penetration room. The penetration room coolers are completely contained within their respective spaces and form closed loop systems.

The pump room coolers may be operated manually during occupation of the room but normally operate only in conjunction with the pump motors they serve. The pump room coolers start automatically upon initiation of the respective pumps.

Operation of the penetration room coolers is controlled by a handswitch or SIS.

One of the two auxiliary/fuel building normal exhaust fans runs continuously during normal plant operations. The standby fan is designed to start either automatically on failure of the operating fan or on manual initiation.

A differential pressure indicator controller, located across the charcoal adsorber, modulates a damper downstream of the filter train to maintain a constant system resistance as the filters load up. This control arrangement will assure a constant system flow. Exhaust hoods are provided over the sample sink located in the auxiliary building sample room. Exhaust flow through the sample room hood is constant whether the sink is in use or not.

The laundry decontamination facility dryer air supply and exhaust system is a self-contained system and does not interface with any other HVAC system. The system operates automatically based on dryer usage. When one or more dryers are started, inlet dampers automatically open to bring outside air into the dryers. The dryers exhaust is mechanically aided by the system exhaust fan. The exhaust air is filtered through a prefilter to remove lint, then passes through a HEPA filter to remove any radioactive contaminants that might be in the air stream. The air stream then passes by a radiation detector prior to discharge from the building. If any radiation is detected the system will be shut down automatically.

The main steam tunnel exhaust system is initiated manually. One of the two main steam enclosure building exhaust fans runs continuously during normal plant operation. The standby fan is designed to start either automatically on failure of the operating fan or on manual initiation. The motor-operated discharge isolation dampers (one associated with each fan) operate in conjunction with their corresponding fans.

The auxiliary building ductwork infiltration air isolation system consists of two dampers in a series arrangement in each system which penetrates the auxiliary building and must be

isolated following a LOCA. Each damper of a pair is powered from a separate Class 1E source to assure closure and will close automatically upon receipt of an SIS.

In the event of a radioactive release from a fuel handling accident in the fuel building, the portion of the auxiliary/fuel building normal exhaust system serving the fuel building

is automatically isolated, and the operating auxiliary/fuel building normal exhaust fan is manually switched to the low speed to maintain the exhaust flow from the auxiliary building.

The charcoal adsorber train is monitored for charcoal bed temperature. Should the bed temperature exceed 200°F, a computer alarm in the control room would alert the operators of excessive bed heating. To prevent backflow through the system, upstream isolation is provided by a backdraft damper located at the inlet to the filter train. All particulate and HEPA filter banks are provided with local differential pressure indication and differential pressure switches which will alarm excessive pressure drops via the plant computer.

In the event of a fire, the auxiliary/fuel building normal exhaust system can function to purge the auxiliary building of smoke.

Based on the outside air design conditions, as described in Table 9.4-1, design space heat loads, and operation of the auxiliary building HVAC systems as described above, the relative humidity in the auxiliary building will not normally exceed 70 percent.

Following a loss of offsite power, certain areas of the auxiliary building will experience temperatures higher than their normal ambient design temperatures. These areas and their resultant temperatures are given in Table 3.11-1. In none of the affected areas does the temperature increase affect either the safe operation or the ability to achieve and maintain the safe shutdown of the plant.

EMERGENCY OPERATION - In the event of a LOCA, those systems which penetrate the auxiliary building boundaries (excluding the emergency exhaust system) are automatically isolated and the emergency exhaust system is automatically started. The emergency exhaust system takes suction on all levels of the auxiliary building and processes the exhaust air through the emergency exhaust charcoal adsorption train (Section 9.4.2) for cleanup prior to monitoring and discharge through the unit vent.

Following a LOCA, if the hydrogen purge system is used, the air purged from the containment will be ducted to the emergency exhaust system for processing and release through the unit vent. To protect the ductwork system from over-pressurization and to provide a means of maintaining the hydrogen purge system flow within design limits, a globe valve is located downstream of the outboard hydrogen purge containment isolation valve. The portion of the system between the outboard isolation valve and the globe valve is piping, and the portion after the globe valve is ductwork. The valve is located in the south electrical penetration room and is manually adjustable from there. The system

flow can be maintained within the design limits as the containment pressure decreases by adjusting the valve as necessary to achieve the required downstream pressure.

9.4.3.3 Safety Evaluations

Safety evaluations are numbered to correspond to the safety design bases in Section 9.4.3.1.

SAFETY EVALUATION ONE - The safety-related portions of the auxiliary building HVAC systems are located in the auxiliary and fuel buildings. These buildings are designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other appropriate natural phenomena. Sections 3.3, 3.4, 3.5, 3.7(B), and 3.8 provide the bases for the adequacy of the structural design of these buildings.

SAFETY EVALUATION TWO - The safety-related portions of the auxiliary building HVAC systems are designed to remain functional after a SSE. Sections 3.7(B).2 and 3.9(B) provide the design loading conditions that were considered. Sections 3.5, 3.6, and 9.5.1 provide the hazards analyses to assure that a safe shutdown, as outlined in Section 7.4, can be achieved and maintained.

SAFETY EVALUATION THREE - The design of the auxiliary building HVAC systems provides complete redundancy and, as indicated by Table 9.4-9, no single failure will compromise the system's safety functions. All vital power can be supplied from either onsite or offsite power systems, as described in Chapter 8.0.

SAFETY EVALUATION FOUR - The pump room coolers, the penetration room coolers, the emergency exhaust system, and the auxiliary building isolation provisions are initially tested with the program given in Chapter 14.0. Periodic in-service functional testing is done in accordance with Section 9.4.3.4.

Section 6.6 provides the ASME Boiler and Pressure Vessel Code, Section XI requirements that are appropriate for the pump room and the penetration room coolers.

SAFETY EVALUATION FIVE - Section 3.2 delineates the quality group classification and seismic category applicable to the safety-related portions of the auxiliary building HVAC systems. All the power supplies and control functions necessary for safe function of the pump room coolers, penetration room coolers, emergency exhaust system, and auxiliary building isolation provisions are Class 1E, as described in Chapters 7.0 and 8.0.

SAFETY EVALUATION SIX - Section 9.4.3.2.3 describes the provisions made to assure the isolation of the auxiliary building following a DBA.

SAFETY EVALUATION SEVEN - The emergency exhaust system maintains a negative pressure in the auxiliary building of not less than 1/4 inch w.g., following a LOCA. The system will collect and process potential ECCS leakages and the effluent purged from

the containment via the hydrogen purge system. The system is monitored for radioactivity downstream of the filter adsorber unit prior to release through the unit vent.

SAFETY EVALUATION EIGHT - The ESF pump room coolers have sufficient cooling capacity to maintain the ESF pump room at 122°F or below when the ESF pumps are operating at rated load.

9.4.3.4 Tests and Inspections

Preoperational testing is described in Chapter 14.0. Filters and adsorbers located within the auxiliary/fuel building normal exhaust filter adsorber unit are tested in the manufacturer's shop, after initial installation, and subsequent to each filter or adsorber change. Interim tests and inspections will be performed every 18 months in accordance with the requirements of Regulatory Guide 1.140.

All charcoal adsorbers are factory tested in accordance with ASTM D3803-1989 to exhibit a decontamination efficiency of no less than 99.9 percent for elemental iodine and 98 percent for methyl iodide. Sample charcoal canisters will be tested for efficiency in an independent laboratory, using radiomethyl iodide tracers. Used activated charcoal adsorber samples are laboratory tested per the protocols of ASTM D3803-1989 for a methyl iodide penetration of less than 2% when tested at 30°C and 70% relative humidity per Technical Specification 5.5.11.c. Inplace testing is performed with a suitable refrigerant in accordance with the procedures set forth in ANSI N510.

Prefilters do not undergo factory or inplace testing since no credit is taken for removal of particulates.

HEPA filters are factory tested with monodispersed DOP aerosol to demonstrate a minimum particulate removal efficiency of no less than 99.97 percent for 0.3 micron particulates. In-place leak testing will be carried out with cold polydisperse DOP. Testing will be in accordance with the procedures set forth in ANSI N510.

All safety-related systems and boundary isolation provisions will undergo preoperational testing prior to plant startup. All nonsafety-related systems undergo acceptance testing prior to plant startup.

One type of each safety-related fan (pump room coolers and penetration room coolers) will be tested in accordance with AMCA Standard 210, "Laboratory Methods of Testing Fans for Rating Purposes."

Major components are accessible during normal plant operation for inspection, maintenance, and periodic testing.

9.4.3.5 Instrumentation Applications

Indication of the operational status of safety related fans is provided in the control room.

The auxiliary/fuel building normal exhaust fans, the main steam enclosure building exhaust fans, the auxiliary building supply air unit, and the main steam enclosure building supply air unit are operable from the control room. All other fans are locally operable.

An indication of the position of automatic building isolation dampers is provided in the control room.

Thermostats, located in both the various levels of the building and the HVAC ductwork, control space temperatures.

The amount of filter loading for all filters associated with both the air handlers and the filter adsorbers is available at the unit.

All instrumentation provided with the auxiliary/fuel building normal exhaust filter adsorber unit is as required by Regulatory Guide 1.140.

High temperature computer alarms for each of the ESF pump rooms and the electrical penetration room are provided in the control room.

9.4.4 TURBINE BUILDING HVAC

The turbine building HVAC systems consist of the main building heating and ventilation systems, the lube oil room ventilation and heating system, the computer room HVAC system, the conference room HVAC system, the condenser air removal filtration system, the battery room ventilation and cooling system, and the EHC cabinet room air-conditioning system.

The main building ventilation system provides outside air for ventilation and cooling for each level of the turbine building. The main building ventilation system serves the turbine building, the communication corridor, and the battery rooms.

The lube oil room ventilation and heating system provides outside air for ventilation and cooling or heating, as required, for the equipment within the lube oil room.

The computer room HVAC system provides a suitable environment for the equipment and personnel comfort.

The conference room HVAC system provides a suitable environment for personnel comfort.

The condenser air removal filtration system collects and processes the noncondensables from the condenser.

The battery room cooling and ventilation system serves to dilute the hydrogen emitted from the batteries.

The EHC cabinet room air-conditioning system provides a suitable environment for the equipment.

9.4.4.1 Design Bases

9.4.4.1.1 Safety Design Bases

The turbine building HVAC systems serve no safety function; however, those dampers and ductwork in the condenser air removal filtration system which are required to provide isolation of the auxiliary building are safety related and are required to function following a DBA and to achieve and maintain the plant in a safe shutdown condition.

SAFETY DESIGN BASIS ONE - The auxiliary building isolation provisions are protected from the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, and external missiles (GDC-2). The isolation provisions for the auxiliary building remain functional after a safe shutdown earthquake and perform their intended function following a postulated hazard, such as a fire, internal missiles, or pipe break (GDC-3 and 4).

SAFETY DESIGN BASIS TWO - The safety functions of the condenser air removal filtration system can be performed, assuming a single active component failure coincident with the loss of offsite power.

SAFETY DESIGN BASIS THREE - Active components of the condenser air removal filtration system are capable of being tested during plant operation.

SAFETY DESIGN BASIS FOUR - The safety-related auxiliary building isolation provisions are consistent with the quality group classification assigned by Regulatory Guide 1.26 and with the seismic category assigned by Regulatory Guide 1.29. The power supply and control functions must be in accordance with Regulatory Guide 1.32.

9.4.4.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - The main building ventilation system supplies outside air for ventilation and cooling to maintain the turbine building average ambient temperature below 110°F. The main building heating system is designed to maintain the average ambient temperature above 60°F.

POWER GENERATION DESIGN BASIS TWO - The lube oil room ventilation and heating system supplies outside air for cooling or heating, as required, to maintain the lube oil room average ambient temperature between 60°F and 110°F.

POWER GENERATION DESIGN BASIS THREE - The computer room HVAC system maintains the average room temperature between 60°F and 72°F and a relative humidity of 50 ± 10 percent. Full-capacity, redundant air-conditioning units are provided.

POWER GENERATION DESIGN BASIS FOUR - The conference room HVAC system maintains the average room temperature between 60°F and 78°F.

POWER GENERATION DESIGN BASIS FIVE - The ventilation exhaust systems are designed to meet the requirements of the discharge concentration limits of 10 CFR 20 and the as-low-as-reasonably-achievable dose objective of 10 CFR 50, Appendix I. No filtration of the main turbine building exhaust is required. The condenser air removal filtration system charcoal adsorption train complies with Regulatory Guide 1.140 to the extent discussed in Table 9.4-3.

POWER GENERATION DESIGN BASIS SIX - The condenser air removal filtration system monitors radioactivity in accordance with Regulatory Guide 1.21.

POWER GENERATION DESIGN BASIS SEVEN - The battery room cooling and ventilation system maintains the average ambient temperature between 60°F and 90°F.

POWER GENERATION BASIS EIGHT - The EHC cabinet room air-conditioning and ventilation system limits the temperature to a maximum of 100°F.

9.4.4.2 System Description

9.4.4.2.1 General Description

Figure 9.4-4 shows the flow diagram of the turbine building HVAC systems.

The main building ventilation system utilizes outside air as a cooling medium. Air is distributed throughout the turbine building and communication corridor by supply units located on the periphery of the building. Outside air, supplied directly, provides cooling for the summer months. During the winter months of plant operation, a reduced quantity of outside air is required for building cooling. The outside air is mixed with turbine building (recirculated) air for tempering during this mode of operation. During plant shutdown in the winter, heating is provided by strategically located electric and hot-water unit heaters.

The turbine building air is exhausted to the atmosphere by exhaust fans located within louvered penthouses on the roof.

Smoke removal in the turbine building in the event of a fire is discussed in Section 9.5.1.

The battery rooms are ventilated by a branch duct from the outside air supply units. A chilled-water coil is provided within the supply air duct to maintain the temperature conditions within these rooms. The rooms are pressurized slightly by the supply air and relieved through a transfer grille into the turbine building. The rate of supply air into the battery rooms will be sufficient to dilute the hydrogen emitted from the batteries to a value well below the flammability, and, hence, the explosive limits.

The lube oil room ventilation system utilizes outside air as a cooling medium. A heating coil is provided for tempering the outside air during winter plant operation and plant shutdown. The lube oil room is exhausted to the atmosphere.

The computer room HVAC system utilizes chilled water for cooling and dehumidification, a hot-water coil for heating, and a humidifier. The computer room air-conditioning unit operates in a complete recirculation mode. Fresh air is provided by a branch duct from an outside air supply unit (servicing the communication corridor) and is relieved through a transfer grille.

The condenser air removal filtration system collects and processes the noncondensables from the condenser (through the mechanical vacuum pumps) and other potential sources of radioactivity. The effluents from these components are diluted with turbine building air, approximately 10 to 1, upstream of the filtration unit to dilute the concentration of noble gases, and moisture content. The condenser air removal filtration system is monitored for radioactivity upstream of the adsorber train. Redundant fans are provided to assure system reliability. The condenser air removal filtration system discharges through the unit vent after processing through the adsorber train.

Based on the source terms provided in Section 11.1 and the dose evaluation provided in Section 11.3 the exhaust systems meet the objective of 10 CFR 50, Appendix I, and the limits of 10 CFR 20.

The conference room air-conditioning system utilizes chilled water for cooling. The conference room air-conditioning unit operates in a complete recirculation mode. Fresh air is provided by a branch duct from an outside air supply unit (servicing the communication corridor) and is relieved through a transfer grille.

The air-conditioning system for the EHC cabinet room utilizes two ductless HVAC loops for cooling. Each EHC cabinet room HVAC loop consists of a rooftop condenser unit and two fan units and utilizes an R-410A refrigerant. Separately provided air conditioners serve as backups to the ductless HVAC loops.

9.4.4.2.2 Component Description

Codes and standards applicable to turbine building ventilation systems are listed in Tables 3.2-1 and 9.4-10.

The turbine building ventilation systems are designed and constructed in accordance with codes and standards comparable with quality group D.

AIR HANDLING UNITS - Each main building supply unit consists of a fan section, a medium-capacity filter box (with provisions for future filters), and an electric motor driver. Some units are also equipped with mixing boxes.

The communication corridor supply unit consists of a fan section, a medium-capacity filter box, a mixing box, and an electric motor driver.

The lube oil room supply air unit consists of particulate filters, a hot-water heating coil, a centrifugal fan, and an electric motor driver.

Each computer room fan-coil unit consists of particulate filters, a chilled-water cooling coil, a hot-water heating coil, a humidifier, a centrifugal fan, and an electric motor driver.

The conference room fan-coil unit consists of particulate filters, a chilled-water cooling coil, a centrifugal fan, and an electric motor driver.

Each EHC cabinet room fan unit consists of a particulate filter, a blower, an electric motor driver, and a condensate drain line. Each EHC cabinet room rootop unit consists of a compressor and a condenser.

The backup room air-conditioners consist of a particulate filter, a centrifugal blower, an electric motor driver, an evaporator, a compressor and a condenser.

COOLING COILS - Each battery room cooling coil is chilled-water type.

FILTER UNIT - The condenser air removal filtration unit consists of moderate efficiency prefilters, HEPA filters, and charcoal adsorption beds.

FANS - The main building exhaust fans are vaneaxial fans with electric motor drivers.

The lube oil room and condenser air removal system exhaust fans are centrifugal fans with electric motor drivers.

The toilet areas and the elevator machine room exhaust fans are centrifugal fans with electric motor drivers.

UNIT HEATERS - Hot-water unit heaters are used to provide heating in the main building. Electric unit heaters provide heating in the stairwells. Each unit heater consists of a coil and a fan with an electric motor driver.

FIRE DAMPERS - Fire dampers are located in fire barriers as necessary to maintain the fire rating of the barriers. Dampers are the 3-hour-rated curtain type.

ISOLATION DAMPERS - Where a means of system isolation is required, parallel-blade-type dampers are utilized. The type of operator used is dependent upon the specific design and/or usage requirements.

FLOW CONTROL DAMPERS - Opposed-blade-type dampers are utilized, as necessary, to provide a means of system balancing.

BACKDRAFT DAMPERS - Backdraft dampers are employed, where required, to maintain the proper direction of air flow.

TORNADO DAMPERS - Tornado dampers are employed where isolation from the effects of extreme wind or tornado conditions is required. These dampers close with the flow produced by the differential pressure associated with the tornado or high winds.

Further information regarding the turbine building ventilation system components is provided in Table 9.4-10.

9.4.4.2.3 System Operation

MAIN BUILDING HEATING AND VENTILATION SYSTEM - During the summer mode of operation, the system utilizes 100 percent outside air for cooling, with all supply units operating. During the winter mode of system operation with the plant operating, only selected outside air supply units are operating, and these are in a partial recirculation mode. Likewise, the number of exhaust fans operating is reduced to correspond to the outside air requirements during this mode of system operation. Unit heater operation may be initiated to provide supplemental heating in low equipment heat load areas. The turbine building is maintained between 60 and 110°F.

Unit heaters are provided for building heating during plant shutdown. Hot water is utilized as the heating medium. The unit heaters are controlled by local thermostats which will energize the heater whenever the building temperature reaches 60°F.

BATTERY ROOM COOLING AND VENTILATION SYSTEM - The branch ducts from the main building ventilation system to the battery rooms are provided with chilled-water coils for cooling. The battery rooms are maintained between 60 and 90°F.

LUBE OIL ROOM VENTILATION AND HEATING SYSTEM - The lube oil room is served by independent supply and exhaust ventilation systems. The lube oil supply system takes suction from the outside and supplies it directly to the space. Cooling is accomplished by the outside air. A hot-water heating coil, located in the supply system, provides the required heating. The lube oil room exhaust system takes suction from the space and discharges it directly to the atmosphere. The lube oil room is maintained between 110 and 60°F.

When the room air temperature falls below 66°F, the temperature controller associated with the heating coil activates the supply unit heating control system. The supply unit heating coil is supplied from a secondary hot-water loop which is, in turn, supplied from the plant heating system.

The lube oil room supply unit heating control system consists of a temperature controller. When the temperature is 60-66°F, the temperature controller modulates the amount of heating accordingly. The temperature controller controls the secondary loop temperature by regulating the amount of hot water which enters the secondary loop of

the heating coil. During prolonged cold weather operation, the temperature control valve may be opened to maintain heating so the supply and exhaust fans will continue to run.

A temperature switch located downstream of the coil is provided to trip the supply air unit, should the supply air temperature drop below 40°F, to protect the coil from freezing.

COMPUTER ROOM HVAC SYSTEM - The computer room HVAC system is controlled by a room thermostat. The thermostat controls cooling and heating by modulating the respective three-way mixing valves. The room temperature is maintained between 60 and 72°F. The humidifier will be initiated by a moisture switch located in the air return to the unit. The moisture switch will initiate the cooling cycle when the room humidity approaches 60 percent and deactivates the cycle when the humidity reaches 55 percent.

CONFERENCE ROOM HVAC SYSTEM - The conference room air-conditioning unit is controlled by a room thermostat which cycles the supply fan. Cooling is accomplished by circulating chilled water through the cooling coil. The room temperature is maintained between 60 and 78°F.

CONDENSER AIR REMOVAL FILTRATION SYSTEM - The condenser air removal filtration system is manually initiated by a local handswitch. One of the two exhaust fans runs continuously during normal operations. The standby fan is designed to start either automatically on failure of the operating fan or on manual initiation.

A differential pressure-indicating controller, located across the charcoal adsorber, modulates a damper downstream of the filter train to maintain a constant system resistance as the particulate filters load up. This control arrangement will assure a constant system flow.

EHC CABINET ROOM HVAC SYSTEM - Each EHC cabinet room HVAC loop is controlled by its associated room thermostat which cycles the fan units and condenser unit. The room temperature is limited to a maximum of 100°F.

The backup room air-conditioners are manually initiated from the unit control panel. Each room air conditioner is controlled by the unit thermostat, which cycles the compressor. The room temperature is limited to a maximum of 100°F.

9.4.4.3 Safety Evaluation

Safety evaluations are numbered to correspond to the safety design bases in Section 9.4.4.1.

SAFETY EVALUATION ONE - The safety-related portions of the condenser air removal filtration system are located in the auxiliary building. This building is designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other appropriate natural phenomena. Sections 3.3, 3.4, 3.5, 3.7(B), and 3.8 provide the bases for the adequacy of the structural design of this building. The

safety-related portions of the condenser air removal filtration system are designed to remain functional after a SSE. Sections 3.7(B).2 and 3.9(B) provide the design loading conditions that were considered. Sections 3.5, 3.6, and 9.5.1 provide the hazards analyses to assure that a safe shutdown, as outlined in Section 7.4, can be achieved and maintained.

SAFETY EVALUATION TWO - The design of the safety-related portions of the condenser air removal filtration system provides complete redundancy, and no single failure will compromise the system's safety functions. All vital power can be supplied from either onsite or offsite power system, as described in Chapter 8.0.

SAFETY EVALUATION THREE - The auxiliary building isolation provisions are initially tested with the program given in Chapter 14.0. Periodic in-service functional testing is done in accordance with Section 9.4.4.4.

SAFETY EVALUATION FOUR - Section 3.2 delineates the quality group classification and seismic category applicable to the safety-related portions of the condenser air removal filtration system. All the power supplies and control functions necessary for safe function of the auxiliary building isolation provisions are Class 1E, as described in Chapters 7.0 and 8.0.

9.4.4.4 Tests and Inspections

Preoperational testing is described in Chapter 14.0.

Filters and adsorbers for the condenser air removal filtration system will be tested in the shop, after initial installation, and subsequent to each filter or adsorber change. Following installation of the filters and adsorbers, interim tests and inspections will be performed in accordance with the requirements of Regulatory Guide 1.140.

Charcoal adsorbers will be qualified per Regulatory Guide 1.140. Charcoal batch samples will be factory tested with radiomethyl iodide tracers at 25°C and 70 percent relative humidity to exhibit a decontamination efficiency of no less than 99.9 percent for elemental iodine and 98 percent for methyl iodide. Sample charcoal will be tested for impregnant efficiency in an independent laboratory using radiomethyl iodide tracers. Inplace testing is performed with a suitable refrigerant, in accordance with the procedures set forth in ANSI N510, to check for bed bypass leakages.

Prefilters will not undergo factory or inplace testing since no credit is taken for removal of particulates.

HEPA filters will be factory tested with monodispersed DOP aerosol to demonstrate a minimum particulate removal efficiency of no less than 99.97 percent for 0.3 micron particulates. Inplace leak testing will be carried out with cold polydispersed DOP. Testing will be in accordance with the procedures set forth in ANSI N510.

Major components are accessible during normal plant operation for inspection, maintenance, and periodic testing.

All safety-related boundary isolation provisions will undergo preoperational testing prior to plant start-up.

9.4.4.5 Instrumentation Applications

Indication of condenser air removal system exhaust fan operational status is provided in the control room.

An indication of the position of all building isolation dampers associated with the condenser air removal filtration system is provided in the control room.

A temperature-sensor element is provided for the charcoal adsorber to indicate excessive bed heating.

An alarm is provided in the control room to indicate high radiation in the condenser air removal filtration system.

All instrumentation provided with the filter/adsorber unit is as required by Regulatory Guide 1.140.

Thermostats, located in the various levels, control space temperature.

Local differential pressure indication is provided across each particulate filter bank.

9.4.5 RADWASTE BUILDING HVAC

The radwaste building HVAC system functions to provide a suitable atmosphere for equipment and personnel occupation.

9.4.5.1 Design Bases

9.4.5.1.1 Safety Design Bases

This system serves no safety function. Failure of the system does not affect safe shutdown of the plant.

9.4.5.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - The radwaste building HVAC system provides fresh air ventilation at a rate of at least 0.1 cfm per square foot of floor area.

POWER GENERATION DESIGN BASIS TWO - The radwaste building HVAC system maintains the temperature in the control rooms, the sample laboratory, and drumming

area between 60 and 85°F. All other areas of the building will be maintained between 60 and 104°F.

POWER GENERATION DESIGN BASIS THREE - The exhaust system inhibits exfiltration by exhausting approximately 10 percent more air than is being supplied to the building, the difference being made up by infiltration into the building.

POWER GENERATION DESIGN BASIS FOUR - The ventilation exhaust system is designed to meet the requirements of the discharge concentration limits of 10 CFR 20 and the ALARA dose objective of 10 CFR 50, Appendix I. The charcoal adsorption train complies with Regulatory Guide 1.140 to the extent discussed in Table 9.4-3.

9.4.5.2 System Description

9.4.5.2.1 General Description

The radwaste building heating, ventilating, and air-conditioning system shown in Figure 9.4-5 consists of fans, heating coils, cooling coils, a filter train, and its associated ductwork, dampers, and controls. Local unit heaters are used to provide supplemental heating. Fan-coil units are used for cooling the evaporator rooms, control rooms, and the sample laboratory. Local fan-coil units are used to provide additional supplemental cooling.

The radwaste building is served by an outside air supply system which provides fresh cooled or heated air to each of the various levels of the building.

The radwaste building exhaust system takes suction from all levels of the radwaste building, processes the exhaust through the filter adsorber train, and discharges it through the building vent. The building vent extends 10 feet above the roof of the radwaste building. Radiation monitors are provided to sample effluents. All exhaust air from the radwaste building is through the radwaste building exhaust system.

The radwaste building exhaust system is designed to inhibit exfiltration. Air flow patterns are from areas of potentially lesser contamination to areas of greater contamination.

Based on the source terms provided in Section 11.1 and the dose evaluation provided in Section 11.3, the exhaust system meets the objective of 10 CFR 50, Appendix I, and the limits of 10 CFR 20.

9.4.5.2.2 Component Description

Codes and standards applicable to the radwaste building HVAC system are listed in Tables 3.2-1 and 9.4-11.

The radwaste building HVAC systems are designed and constructed in accordance with codes and standards comparable with quality group D.

SUPPLY AIR UNIT - The radwaste building supply air unit consists of particulate filters, a hot-water heating coil, a chilled-water cooling coil, a centrifugal fan, and an electric motor driver.

RECIRCULATION UNITS - Fan-coil units are used to provide the cooling for the evaporator rooms, control rooms, and sample laboratory. Local fan-coil units are used to provide supplemental cooling of the basement and ground floors. Each unit consists of particulate filters, a chilled-water cooling coil, a centrifugal fan, and an electric motor driver. The main control room fan-coil unit is also provided with a hot-water heating coil to provide heating.

FILTER UNIT - The radwaste building filtration unit consists of moderate efficiency prefilters, HEPA filters, and charcoal adsorption beds.

FANS - The radwaste building exhaust fans are centrifugal fans with electric motor drivers. The radwaste building fume hood booster fan is an axial fan driven by an electric motor via drive belts.

The access tunnel transfer fan is a propeller type with an electric motor driver.

UNIT HEATERS - Hot-water unit heaters are used to provide supplemental heating. Each unit heater consists of a coil and a fan with an electric motor driver.

FIRE DAMPERS - Fire dampers are located in fire barriers, as necessary, to maintain the fire rating of the barriers. Dampers are the 3-hour-rated curtain type.

ISOLATION DAMPERS - Where a means of system isolation is required, parallel-blade-type dampers are utilized. The type of operator used is dependent upon the specific design and/or usage requirements.

FLOW CONTROL DAMPERS - Opposed-blade-type dampers are utilized, as necessary, to provide a means of system balancing.

BACKDRAFT DAMPERS - Backdraft dampers are employed, where required, to maintain the proper direction of air flow.

9.4.5.2.3 System Operation

The radwaste building supply air unit is started manually. The supply air unit draws in outside air, filters it through low efficiency particulate filters, either cooling with a chilled-water coil or heating with a hot-water coil, and distributes the conditioned air to the various floors of the radwaste building. Fan-coil units are used for cooling the evaporator rooms, control rooms, and sample laboratory. Local fan-coil units are used to provide supplemental cooling in the basement and ground floors. Space heating is provided by the outside air unit and local unit heaters.

The heating or cooling mode of operation of the outside air supply unit is controlled by the outside air temperature. When the outside air temperature exceeds 80°F, chilled-water cooled outside air is supplied to the building. When the outside air temperature is between 48 and 80°F, unconditioned outside air is supplied to the building. When the outside air temperature is below 48°F, the heating system is operational. These operations are controlled by temperature switches, one associated with each coil, located in the ductwork upstream of the coils, which sense the outside air temperature and function accordingly.

When the outside air temperature rises above 80°F, the temperature switch associated with the cooling system activates the supply unit cooling control system. This control system then functions to maintain a constant supply air temperature of 75°F by modulating the flow of chilled water to the coil.

While the outside air temperature is between 48 and 75°F, the supply unit continues to supply unconditioned air to the building.

When the outside air temperature falls below 48°F, a temperature switch activates the supply unit heating control system. The supply unit heating coil is supplied from a secondary hot-water loop which is, in turn, supplied from the plant heating system.

The supply unit heating control system consists of temperature transmitters, located on each level, which sense the corridor temperature and transmit a corresponding signal to a single temperature controller. When any one of these signals indicates that a corridor temperature is below 60°F, the temperature controller then modulates the amount of heating accordingly. The temperature controller controls the secondary loop temperature by regulating the amount of hot water which enters the secondary loop of the heating coil.

A temperature switch is provided downstream of the coils. This temperature switch will trip the supply unit, should the supply air temperature drop below 40°F, to protect the coils from freezing.

Supplemental heating is provided by unit heaters located throughout the building. Each unit heater is controlled thermostatically to maintain the space design requirements of 60°F or above.

The radwaste building exhaust system is started manually. One of the two radwaste building exhaust fans runs continuously during normal operations. The standby fan is designed to start either automatically on failure of the operating fan or on manual initiation.

The radwaste building supply air unit fan and the exhaust fans are interlocked to prevent the supply fan from being started before the exhaust fan.

A differential pressure-indicating controller, located across the filter train, modulates a damper downstream of the filter train to maintain a constant system resistance as the particulate filters load up. This control arrangement will assure a constant system flow and thus assure that the system will always inhibit exfiltration.

The recirculation fan-coil units are initiated manually and are controlled by their respective thermostats which cycle the supply fans.

9.4.5.3 Safety Evaluation

The operation of the radwaste ventilation system is not required for the safe shutdown of the plant or for mitigating the consequences of a design basis accident.

9.4.5.4 Tests and Inspections

Preoperational testing is described in Chapter 14.0.

Filters and adsorbers are tested in the manufacturer's shop, after initial installation and subsequent to each filter or adsorber change. Following installation of the filters and the adsorbers, interim tests and inspections are performed in accordance with the requirements of Regulatory Guide 1.140.

Charcoal adsorbers are qualified per Regulatory Guide 1.140. Charcoal batch samples are factory tested with radiomethyl iodide tracers at 25°C and 70 percent relative humidity to exhibit a decontamination efficiency of no less than 99.9 percent for elemental iodine and 98 percent for methyl iodide.

Sample charcoal is tested for impregnant efficiency in an independent laboratory using radiomethyl iodide tracers. Inplace testing is performed with a suitable refrigerant, in accordance with the procedures set forth in ANSI N510, to check for bed bypass leakage.

HEPA filters are factory tested with monodispersed DOP aerosol to demonstrate a minimum particulate removal efficiency of no less than 99.97 percent for 0.3 micron particulates. Inplace leak testing is carried out with cold polydisperse DOP. Testing is in accordance with the procedures set forth in ANSI N510.

Prefilters do not undergo factory or inplace testing, since no credit is taken for the removal of particulates.

Major components are accessible during normal plant operation for inspection, maintenance, and periodic testing.

9.4.5.5 Instrumentation Applications

Fan-running lights and fan-trip alarms are provided in the control room.

All exhaust fans are operable from control room.

Thermostats, located at the various levels, control space temperatures.

Temperature-sensor elements are provided downstream of the charcoal adsorbers to indicate excessive bed heating. Local differential pressure indication is provided across each particulate filter bank.

Alarms are provided in the control room to indicate high radiation in the radwaste building and high temperature in the charcoal adsorber beds.

All instrumentation provided with the filtration units is as required by Regulatory Guide 1.140.

9.4.6 CONTAINMENT HVAC

The containment HVAC system consists of the containment shutdown purge, containment minipurge, containment atmosphere control, control rod drive mechanism (CRDM) cooling, cavity cooling, pressurizer skirt cooling, elevator machine room exhaust, the hydrogen mixing fans, and containment cooling system.

The containment shutdown purge system operates during reactor outages to supply outside air into the containment for ventilation and cooling or heating and may also be used, when the reactor is in the cold shutdown mode, to reduce the concentration of noble gases within the containment prior to and during personnel access.

The containment minipurge system is typically used during reactor power operations to reduce the concentration of noble gases within the containment prior to and during personnel access or to equalize internal and external pressures. The system may also have limited use during plant conditions other than reactor operation.

The CRDM cooling system maintains a suitable atmosphere during normal operation within the CRDM shroud to protect and prolong the life of the CRDM coils.

The cavity cooling system maintains a suitable atmosphere within the reactor cavity during normal operation to protect the concrete and the out-of-core neutron detectors.

The pressurizer cooling fan provides the necessary cooling of the lower portion of the pressurizer (skirt and heater connections) when the containment cooler serving that compartment is out of service.

The machine room exhaust fan provides the required ventilation of the containment elevator machine room during normal plant operations.

The functional bases for the containment cooling system and the hydrogen mixing system are described in Sections 6.2.2 and 6.2.5, respectively.

9.4.6.1 Design Bases

9.4.6.1.1 Safety Design Bases

Except for an associated containment penetration, the hydrogen mixing fans, and the containment cooling system, the containment HVAC systems are not safety related. A complete description of the design of the containment cooling system and containment hydrogen mixing system is provided in Section 6.2.2.2.

SAFETY DESIGN BASIS ONE - The containment isolation valves in the system are selected, tested, and located in accordance with the requirements of 10 CFR 50, Appendix A, General Design Criteria 54 and 56, and 10 CFR 50, Appendix J, Type C testing.

SAFETY DESIGN BASIS TWO - The containment purge system containment isolation valves are capable of rapid closure, following their respective DBA (FHA for the shutdown purge valves and LOCA for the minipurge valves), to limit the escape of fission products from the containment.

9.4.6.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - The containment shutdown purge system is designed to maintain a containment ambient air temperature between 50 and 90°F, when the reactor is shut down. The shutdown purge system supplies fresh air into the containment at a rate of approximately one containment volume air change per every 2 hours for fresh air ventilation.

POWER GENERATION DESIGN BASIS TWO - The design basis flow of 4,000 cfm is based on continuous system operation with an assumed weekly occupancy of 5 hours for any one individual.

The assumptions used in determining the flow rate and resultant airborne activities are consistent with NUREG-0017, Reference 7, Section 12.2. Table 12.2-11 provides the assumed RCS specific activities, failed fuel percentages, RCS leakage rates, and partition factors. Table 12.2-12 provides the airborne concentrations within the containment, assuming a continuous 4,000 cfm purge.

Any individual is allowed to be exposed to the concentrations of Table I Column I of 10 CFR 20, Appendix B, for 40 hours per week or to greater concentrations for a corresponding lesser amount of time. The design bases for the minipurge results in the most limiting factor being approximately 7 times those listed in Table I, Column I and therefore occupancy for an individual would be allowed for nearly 6 hours. In addition, the philosophy of Regulatory Guide 8.15 is to minimize the requirement for wearing respirators through improved ventilation. Therefore, not using the minipurge would be contrary to the philosophy of both 10 CFR 20 and Regulatory Guide 8.15. In order to pass the required flow of 4,000 cfm and use only one set of valves in accordance with

the recommendations of BTP CSB-4, an 18-inch isolation valve was utilized in lieu of the recommended 8-inch valve.

Good engineering practice limits the flow velocities and pressure drops through system valves. With an 18-inch line (velocity = 2,264 fpm), the design flow can be maintained by the supply and exhaust fans designed for a differential pressure of 4.25 and 5.0 inches w.g., respectively. If the system lines remained as designed and the isolation valves were replaced with 8-inch valves with reducers on either side, the supply and exhaust system pressure drops would increase to 9.02 and 10.5 inches w.g. at the design flow. Since the fans cannot create these high differential pressures, the design flow would not be realized and the system would not perform its design function.

The charcoal adsorbers in the discharge of the system comply with Regulatory Guide 1.140, to the extent discussed in Table 9.4-3.

POWER GENERATION DESIGN BASIS THREE - The CRDM cooling system is designed to maintain all CRDM coils below the design temperature limit of 392°F and is in operation any time the reactor coolant temperature is greater than 200°F. The cooling of the air is provided by the containment cooler. During two- and three-fan operation, this is achieved with a containment air temperature of 120°F and a CRDM cooling fan inlet temperature not greater than 165°F. During emergency single-fan operation, CRDM coil temperatures can be maintained below the design limit of 392°F at containment air temperatures lower than 120°F.

POWER GENERATION DESIGN BASIS FOUR - The cavity-cooling system is designed to limit the normal ambient temperature around the out-of-core neutron detectors. The cavity core concrete temperature is limited to 150°F by air cooling of the reactor vessel supports and reactor coolant pipe whip restraints. The cooling of the cavity air is provided by the containment coolers.

POWER GENERATION DESIGN BASIS FIVE - The pressurizer cooling fan will limit the temperature in the area below the pressurizer skirt to approximately 120°F by inducing air from the containment for cooling.

POWER GENERATION DESIGN BASIS SIX - The elevator machine room exhaust fan is designed to provide sufficient air changes in the machine room to maintain a suitable environment for the equipment located there.

9.4.6.2 System Description

9.4.6.2.1 General Description

Piping and Instrumentation Diagrams for the containment shutdown purge system, the containment minipurge system, and the CRDM and cavity-cooling system described below are shown in Figure 9.4-6.

The containment shutown purge supply system supplies fresh outside air, tempered or cooled, as required, to the containment. During operation of the containment shutdown purge supply system, the containment shutdown purge exhaust fan takes suction from the containment through the containment purge exhaust system and containment purge filtration unit and discharges it through the unit vent.

Prior to entrance into the containment during reactor power operations, the containment minipurge system may be used to reduce the concentration of noble gases, and halogens in the containment atmosphere. The containment minipurge supply system supplies air to the containment. The containment minipurge exhaust fan exhausts from the containment through the containment purge exhaust system. The exhaust air is processed through the containment purge filter-adsorber unit and discharged through the unit vent. The containment minipurge system and the ctmt purge exhaust system will maintain containment occupant exposure from airborne activity to less than those specified in 10 CFR 20. Based on the source terms provided in Section 11.1 and the dose evaluation provided in Section 11.3, the exhaust system meets the objective of 10 CFR 50, Appendix I.

The CRDM cooling system induces containment air into the CRDM shroud and exhausts it through the fans. Four fans are provided for the system, but the required flow of cooling air, per Power Generation Design Bases Three, can be achieved with one, two, or three fans.

The cavity-cooling system induces air supplied to the incore instrument tunnel by the containment coolers into the cavity for cooling. The rate of airflow for the cavity cooling fan is based on dissipating the heat from the vessel, nozzle support system, insulation losses, vessel piping, and gamma heating.

The cavity-cooling system fans exhaust from the cavity to the containment atmosphere. Normally, one fan is in operation to provide the necessary airflow.

As described in Section 6.2.2.2 and shown in Figure 6.2.2-7, the containment coolers supply air to the lower portions of the steam generator compartments. The air is exhausted from these compartments by means of the hydrogen mixing fans, which have a high discharge velocity, directing the airstream upward. This action in conjunction with the operation of the CRDM cooling system and the cavity cooling systems, which take suction from the lower area of the containment and discharge it upwards, produces a normal containment air flow circulation path from the bottom to the top of the containment.

9.4.6.2.2 Component Description

Codes and standards applicable to the containment HVAC systems are listed in Tables 3.2-1 and 9.4-12. The containment penetrations and containment isolation valves are designed and constructed in accordance with the requirements of quality group B and are seismic Category I. The cavity cooling system, CRDM cooling system, pressurizer

skirt cooling, elevator machine room exhaust, and the containment purge systems (excluding the containment isolation provisions) are designed and constructed in accordance with codes and standards comparable with quality group D.

NONESSENTIAL AIR HANDLERS - The only nonessential air handlers in the containment HVAC systems are the containment shutdown purge supply air unit and the containment minipurge supply air unit.

The containment shutdown purge supply air unit consists of particulate filters, heating coil, cooling coil, centrifugal fan, and electric motor driver.

The containment minipurge supply air unit consists of particulate filters, heating coil, and centrifugal fan with electric motor driver.

NONESSENTIAL FANS - Those nonessential fans in the containment HVAC systems are the shutdown purge exhaust fan, minipurge exhaust fan, CRDM cooling fans, cavity cooling fans, pressurizer cooling fan, and machine room exhaust fan.

The shutdown purge exhaust fan, minipurge exhaust fan, and the machine room exhaust fan are centrifugal fans with electric motor drivers.

The CRDM cooling fans are centrifugal fans with directly coupled electric motor drivers. The cavity cooling fans, and pressurizer cooling fan are vaneaxial fans with directly coupled electric motor drivers.

NONESSENTIAL FILTER UNITS - There is one nonessential filter unit in the containment HVAC systems--the containment purge exhaust filter/adsorber unit . The unit consists of moderate efficiency prefilters, HEPA filters, and charcoal adsorption beds.

CONTAINMENT ISOLATION VALVES - The containment purge system is the only containment HVAC system which penetrates the containment. The supply and exhaust system both contain four isolation valves. These valves are air-operated butterfly valves.

DEBRIS SCREENS - As shown on Figure 9.4-6, Sheet 4, debris screens are provided on the containment side of the minipurge supply and exhaust isolation valves to prevent the entry of lightweight debris which could preclude tight valve closure. The piping which contains the screens is ANSI B31.1 (150 pound design pressure) piping which is seismically analyzed in accordance with Position C.3 of Regulatory Guide 1.29. The screens are located approximately two pipe diameters away from the isolation valves and are inherently designed to withstand post-LOCA differential pressures due to their rugged design and the negligible pressure drop through the screen material (No. 2 mesh, .063 inch wire with a 76.4 percent free area). The screen material is welded over the 17-inch-diameter opening in a 1/4-inch-thick flange which is bolted into place.

The purge isolation valves and debris screens are located adjacent to the containment wall, outside of the secondary shield walls, and are protected from missiles which could be postulated following a LOCA. Also, motor-operated dampers are located one pipe diameter away from the screens on the containment side. These dampers and the connecting piping provide additional protection for the wire mesh screens.

CONTAINMENT COOLERS - See Section 6.2.2.2.

HYDROGEN MIXING FANS - See Section 6.2.2.2.

ISOLATION DAMPERS - Where a means of system isolation is required, parallel-blade-type dampers are utilized. The type of operator employed is dependent upon the specific design and/or usage requirements.

FLOW CONTROL DAMPERS - Opposed-blade-type dampers are utilized, as necessary, to provide a means of system balancing. In general, these are manually operated. However, some utilize power operators to allow compensation for changes in system resistance occurring during system operation.

BACKDRAFT DAMPERS - Backdraft dampers are employed, where required, to prevent system backflow.

TORNADO DAMPERS - Tornado dampers are employed where isolation from the effects of extreme wind or tornado conditions is required. These dampers close with the flow produced by the differential pressure associated with the tornado or high winds.

FIRE DAMPERS - Fire dampers are located in fire barriers, as necessary, to maintain the fire ratings of the barriers. Dampers are the 3-hour-rated curtain type.

9.4.6.2.3 System Operation

The containment shutdown purge supply system supplies fresh outside air, tempered or conditioned as required, into the containment. During operation of the containment shutdown purge supply system, the containment shutdown purge exhaust fan operates to take suction from the containment through the containment purge exhaust system. The containment exhaust is monitored and processed through the containment purge filter/adsorber unit prior to being released through the unit vent.

The containment minipurge system and the containment shutdown purge system intakes are in a penthouse atop the auxiliary building, which is located approximately 15 feet below and 135 feet horizontally from the diesel exhaust discharge point. This separation is sufficient to provide significant dilution of the diesel exhaust gases; therefore, operation of the diesel during normal plant operations will result in no significant ingestion of exhaust gases into the containment.

The containment shutdown purge supply system ductwork runs along the inside periphery of the containment and discharges to the operating floor. The containment coolers aid in the distribution of the air throughout the remainder of the containment.

The containment shutdown purge supply system and the containment shutdown purge exhaust fan may be operated continuously during shutdown to provide the containment ventilation. This system also serves as the means of heating the containment during plant shutdown.

Prior to entrance into the containment during reactor power operations, the containment minipurge system operates. Operation of the containment minipurge system may be continuous or intermittent during power operations. The minipurge system is designed to reduce the containment noble gas concentration. The system may also have limited use during plant conditions other than reactor operation.

The CRDM cooling system induces containment air into the CRDM shroud for cooling. Four fans are provided for the system, but the required flow of cooling air, per Power Generation Design Bases Three, can be achieved with one, two, or three fans. The ultimate cooling is provided by the containment coolers. The temperature of the effluent air from the CRDM shroud is monitored via the plant computer. Each CRDM fan is provided with a tight shutoff gravity-operated damper to prevent short circuiting through the idle fan.

The cavity cooling system induces air into the cavity for cooling. This air is induced from the instrument tunnel (where it is supplied by the containment coolers), through the hot leg and cold leg restraints and around the neutron shield ring. The rate of airflow is based on dissipating the heat from the nozzle support system, insulation losses from the reactor vessel, reactor coolant piping, and the hot and cold leg restraints, and gamma heating. The cavity cooling system fans exhaust from the cavity to the containment atmosphere. Air is exhausted from the upper regions of the cavity through the reactor vessel supports and through the neutron detector wells. One operating fan has the capability to provide the necessary airflow. The ultimate cooling is provided by the containment coolers. The effluent air temperature from one reactor vessel support, from one detector well, and in one upper cavity region exhaust leg is monitored by the plant computer. In addition, temperature elements are embedded in the cavity, below each reactor vessel support, to monitor concrete temperature.

The pressurizer cooling fan is located near the bottom of the pressurizer compartment. The fan takes suction from the lower region of the pressurizer compartment (and therefore the coolest) and through the ductwork and discharges it in the area immediately below the pressurizer skirt. The fan will operate only when the associated containment cooler is out of service.

The machine room exhaust fan is located on the roof of the machinery equipment room and takes suction from the room. Makeup air is induced from the containment through transfer grilles located in the walls of the room. The machine room exhaust fan will

operate during normal plant operations and during shutdown. It should not be operated during ILRT, to prevent overloading of the fan motor.

Cooling water for the shutdown purge supply unit is supplied by the central chilled water system (Section 9.4.10). Hot water for both the containment shutdown purge supply unit and the containment minipurge supply unit is supplied by the plant heating system (Section 9.4.9).

Discussed below are the power generation operations and shutdown operations of the containment HVAC systems. Because the emergency operation consists only of closing the containment isolation valves, it is discussed under the power generation and shutdown operations.

POWER GENERATION OPERATION - The minipurge system is designed to minimize occupational exposures to as-low-as-reasonably-achievable (ALARA) levels. Instead of personnel entering the containment with airborne activities much greater than MPC and at odds with the philosophy of Regulatory Guide 8.15, the containment will be purged to reduce airborne radioactivity concentrations and exposures in line with the philosophy of 10 CFR 20 and Regulatory Guide 8.15. The minipurge system is designed to be operated continuously to achieve these objectives. The need for continuous operation includes consideration for planned and unplanned entires into the containment and the need to periodically vent excess air from the containment to maintain the pressure near atmospheric conditions.

a. Preplanned Entries

During the first years of commercial operation, daily entry into the containment is planned. This frequency is used by other PWRs. These entries would be from 1/2 to 1-1/2 hours in length, depending on the conditions found within the containment. This type of operation would allow correction of leaks (much smaller than the Technical Specification limits). Early correction, prior to the formation of large mounds of boric acid crystals and the release of significant amounts of radioactivity, will enhance the overall ALARA program at the plant.

b. Unplanned Entries

Unplanned entires inlcude those responding to abnormal indications from within the containment. These indications include leaks, equipment malfunctions, and instrumentation failures. Since these failures could have a significant impact on the continued safe operation of the plant, immediate response is most preferable. Without the continuous operation of the minipurge, the doses received from containment entries will be much higher, unless entries are delayed for significant amounts of time. For instance, if the containment had not been purged for 2 weeks, it would take

65 hours to bring the airborne activity down to the same levels as those maintained with its operation.

c. Containment Pressure Reduction

Instrument air is continuously being vented to the containment from air-operated valves. These valves also dump the air from their accumulators upon actuation. In order to maintain the containment pressure near atmospheric conditions, the minipurge system will be used to release excess air.

One operating plant has experienced over a 1 psig pressure buildup in 24 hours. If this rate were experienced at the Callaway Plant, the containment would have to be vented at least every other day to maintain the containment pressure within the Technical Specification limit of +1-1/2 psig.

The containment minipurge system is manually initiated from the control room. Exhaust from the containment is processed through the containment purge exhaust system charcoal adsorption train prior to being discharged through the unit vent. The containment purge exhaust system is monitored for radioactivity, both upstream and downstream of the charcoal adsorber. The containment purge exhaust system is provided with redundant particulate and gaseous radiation monitors in a seismic Category I section of ductwork directly downstream of the (exhaust) containment isolation valves. Downstream monitoring of the containment purge exhaust system is provided by the radiation monitor in the unit vent. For plant conditions during CORE ALTERATIONS and during movement of irradiated fuel within containment, the function of the monitors is to alarm only and the trip signals for automatic actuation of CPIS may be bypassed. One instrumentation channel at a minimum is required for the alarm only function during plant refueling activities.

A temperature controller located downstream of the containment minipurge system will maintain an offcoil temperature of 50°F during the winter months' operation. The containment minipurge supply unit has no cooling coil and, therefore, when the outside ambient temperature rises above 50°F untempered outside air is supplied to the containment. A temperature switch, located immediately downstream of the shutdown purge supply unit cooling coil, will stop the supply fan if the supply air temperature falls below 40°F, to prevent freezing of the coils.

Normally, each of the four containment coolers will be operating to provide containment cooling capabilities. Although only three coolers are required to provide the proper cooling, four coolers will operate to provide the required air flow distribution. The bulk of this cooled air is supplied to the lower regions of the steam generator compartments. The remaining air is supplied to the instrument tunnel and at each level (operating floor and below) of the containment outside the secondary shield wall. The air supplied to each steam generator compartment is drawn upwards through the compartments by the

hydrogen mixing fans and discharged into the upper elevations of the containment. Each containment cooler is monitored for leaving air temperature and fan vibration via the plant computer. In addition, containment air temperature will also be monitored in the area of each containment cooler intake. Control room indication is provided for both the leaving air and inlet air temperatures.

The hydrogen mixing fans are located in the hatches above the reactor coolant pump motors. Air is drawn from the steam generator compartments by the fans and discharged toward the upper regions of containment. The discharge of the fan has provisions for a minimum throw (distance travel by the air stream) of 100 feet to minimize stratification in the upper regions of containment.

The CRDM cooling system operates normally with three of the four fans, but the required cooling air flow, per Power Generation Design Bases Three, can be achieved with one, two, or three fans. The system is manually initiated from the control room and should be operated any time the reactor coolant system temperature is greater than 200°F.

The CRDM cooling system removes residual heat from the CRDM following a trip of the rods. The CRDM cooling system also aids in removing heat from the upper head area to prevent void formation in the upper head. This is a nonessential operation, but, if available, will protect the CRDM.

The cavity cooling system fan induces containment air from the instrument tunnel, through the reactor coolant piping penetrations, and into the cavity for cooling. Portions of this air are exhausted directly through the reactor vessel supports and the out-of-core neutron detector wells for cooling, and the remaining air is exhausted from the upper portions of the cavity.

The cavity cooling system will maintain the core concrete at a temperature of no greater than 150°F except for the area directly below the seal ring support which is limited to 300°F. Temperatures outside the reactor cavity are described in Section 6.2.2.

The pressurizer cooling fan induces air from the containment to provide cooling of the pressurizer skirt and heater connections when the containment cooler serving the pressurizer compartment is out of service. The system is manually initiated from the control room.

The machine room exhaust fan provides the required ventilation of the machinery equipment room. The fan is manually operated from the control room.

SHUTDOWN OPERATIONS - Once cold shutdown is achieved, the containment shutdown purge system and the elevator machine room exhaust fan are normally required to operate during shutdown operations. Limited use of the containment mini-purge system (rather than the shutdown purge system) may alternatively occur during this period.

The containment shutdown purge system is manually initiated from the control room. Exhaust from the containment is processed through the containment purge exhaust system charcoal adsorption train prior to discharge through the unit vent. The containment purge exhaust system is monitored for radioactivity, both upstream and downstream of the charcoal adsorber. The containment purge exhaust system is provided with redundant particulate and gaseous radiation monitors in a seismic Category I section of ductwork directly downstream of the (exhaust) containment isolation valves. Downstream monitoring of the containment purge exhaust system is provided by the radiation monitor located in the unit vent.

A differential pressure indicator controller, located across the charcoal adsorber, modulates a damper downstream of the filter train to maintain constant system resistance as the particulate filters load up. This control arrangement will assure a constant system flow.

The containment purge charcoal adsorber train is monitored for charcoal bed temperature. Should the bed temperature exceed 200°F, the control room would receive a plant computer alarm to alert the operators of excessive bed heating. Should the bed temperature continue to rise and exceed 300°F, a second computer point would alarm in the control room. To prevent backflow through the system, upstream isolation is provided by a backdraft damper located at the inlet to the filter train.

Temperature controllers, located downstream of the containment shutdown purge supply unit, will regulate the flow of chilled water or hot water to the respective coils to ensure that the containment is maintained between the design temperatures of 50°F and 90°F during shutdown. A temperature switch, located immediately downstream of the supply unit cooling coil, will stop the supply fans if the supply air temperature falls below 40°F to prevent freezing of the coils.

The elevator machine room exhaust fan provides the required ventilation of the machinery equipment room. The fan is manually operated from the control room.

The containment coolers and the hydrogen mixing fans may be operated during refueling operations to provide supplemental air distribution within the containment. Both the hydrogen mixing fans and the containment cooler fans are operated at low speed to reduce noise levels within the containment. The coolers may be operated with the service water to provide supplemental cooling or without service water for supplemental heating.

The containment coolers are operated during containment integrated leak rate testing (ILRT) to maintain uniform containment temperature. The coolers are operated with service water to provide cooling and without service water to provide heating during the test procedure. The fans are operated at low speeds during this elevated pressure condition.

EMERGENCY OPERATIONS - Both the containment shutdown purge and the containment minipurge isolation valves are automatically closed upon receipt of a containment purge isolation signal (CPIS). The CPIS is initiated by receipt of an SIS or by indication of high radioactivity levels in the purge exhaust system process effluents by one of the purge exhaust radiation monitors. Sections 7.2.2 and 7.3.2 discuss these various signals which will generate a CPIS.

The containment purge isolation valves are designed for rapid closure to minimize release of containment effluents following postulated accident conditions. The containment minipurge isolation valves are designed for tight closure within 5 seconds after receipt of an isolation signal. Wire screens are provided on the inboard (containment) side of these valves to preclude the entrance of debris which could prevent tight closure of the minipurge valves. The shutdown purge containment isolation valves are tested by the manufacturer under static conditions for valve closure within 10 seconds. Both these valves are designed to fail closed by spring action upon a loss of power or instrument air. Spectacle flanges are provided inboard the inboard valves and outboard of the outboard valves to facilitate integrated leak rate testing of each individual valve.

Sections 6.2.2 and 6.2.5 provide the description of the containment coolers and the hydrogen mixing fans following a postulated DBA.

9.4.6.3 Safety Evaluation

Safety evaluations are numbered to correspond to the safety design bases in Section 9.4.6.1.

SAFETY EVALUATION ONE- Sections 6.2.4 and 6.2.6 provide the safety evaluation for the system containment isolation arrangement and testability.

SAFETY EVALUATION TWO - A testing program, implemented by the manufacturer, verifies a minipurge containment isolation valve closure time of 5 seconds or less. The containment minipurge containment isolation valves comply with BTP CSB 6-4 to the extent discussed in Table 9.4-13. The shutdown purge containment isolation valve is tested by the manufacturer to verify a closure time of 10 seconds or less under static conditions.

9.4.6.4 Tests and Inspections

Preoperational testing is described in Chapter 14.0.

Filters and adsorbers in the containment purge exhaust system and the containment atmospheric control system are tested in the shop, after initial installation, and subsequent to each filter or adsorber change. Interim tests and inspections are performed annually, after installation, in accordance with the requirements of Regulatory Guide 1.140.

Prefilters do not undergo factory or inplace testing since no credit is taken for removal of particulates in meeting permissible dose rates.

HEPA filters are factory tested with monodispersed DOP aerosol to demonstrate a minimum particulate removal efficiency of no less than 99.97 percent for 0.3 micron particulates. Inplace leak testing is carried out with cold polydisperse DOP. Testing will be in accordance with the procedures set forth in ANSI N5l0.

Charcoal adsorbers are qualified per Regulatory Guide 1.140 and be factory tested in accordance with RDT-M-16-IT to exhibit a decontamination efficiency of no less than 99.5 percent for elemental iodine and 95 percent for methyl iodide. Inplace testing is performed with a suitable refrigerant in accordance with the procedures set forth in ANSI N510.

The containment shutdown purge system and the containment minipurge system, excluding the containment isolation valves, the containment atmospheric control system, CRDM cooling system, cavity cooling system, pressurizer cooling system, and machine room exhaust fan undergo acceptance testing prior to plant startup.

The containment purge valves undergo preoperational testing prior to plant startup. Each valve will be leak rate tested in accordance with 10 CFR 50, Appendix J.

Fans are rated in accordance with AMCA standards.

Major components located outside the containment are accessible during normal plant operation for inspection, maintenance, and periodic testing. Components located inside the containment are accessible during plant shutdown.

9.4.6.5 Instrumentation Applications

Indication of the operational status of the containment purge exhaust fans and all the fans in the containment is provided in the control room.

All fans and air handlers are operable from the control room.

An indication of the position of all isolation dampers is provided in the control room, except cavity cooling fans isolation dampers.

Temperature controllers located in the containment purge ductwork control the containment temperature during shutdown.

The amount of filter loading for all filters associated with both the air handlers and the filter adsorbers is available at the unit.

All instrumentation provided with the containment purge system filter adsorber unit is as required by Regulatory Guide 1.140.

Indication of the levels of gaseous, particulate, and iodine radioactivity being exhausted from the containment and being released through the unit vent is available in the control room.

The temperature of the air leaving one of the detector wells, leaving one reactor vessel support, and leaving the upper cavity area, as well as the concrete temperature below each reactor vessel support, is available in the control room.

The containment pressure relative to the auxiliary building, the containment temperature, and the containment relative humidity are available in the control room.

Each containment cooler is monitored for leaving air temperature and fan vibration via the plant computer. In addition, containment air temperature will also be monitored in the area of each containment cooler intake. Control room indication is provided for both the leaving air and inlet air temperatures.

Each containment cooler fan is operable from the control room.

Each hydrogen mixing fan is operable from the control room and is monitored for fan vibration via the plant computer.

9.4.7 DIESEL GENERATOR BUILDING VENTILATION

The function of the diesel generator building (DGB) ventilation system is to provide a combustion air makeup rate and an environment suitable for the operation of the diesel generators.

9.4.7.1 Design Bases

9.4.7.1.1 Safety Design Bases

The DGB HVAC system, excluding unit heaters, is safety related and is required to function following a DBA and to achieve and maintain the plant in a safe shutdown condition.

SAFETY DESIGN BASIS ONE - The DGB ventilation system is protected from the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, and external missiles.

SAFETY DESIGN BASIS TWO - The DGB ventilation system is designed to remain functional after a SSE and to perform its intended function following a postulated hazard, such as a fire, internal missiles, or pipe break (GDC-3 and 4).

SAFETY DESIGN BASIS THREE - The safety functions of the DGB ventilation system can be performed, assuming a single active component failure coincident with the loss of offsite power (GDC-44).

SAFETY DESIGN BASIS FOUR - The DGB ventilation system is designed so that the active components are capable of being tested during plant operation.

SAFETY DESIGN BASIS FIVE - The DGB ventilation system uses the design and fabrication codes consistent with the quality group classification assigned by Regulatory Guide 1.26 and the seismic category assigned by Regulatory Guide 1.29. The power supply and control functions must be in accordance with Regulatory Guide 1.32.

SAFETY DESIGN BASIS SIX - The DGB ventilation system maintains a suitable atmosphere in the DGB while the diesel is operating. Cooling is accomplished by the outside air.

9.4.7.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - The DGB heating system limits the minimum room temperature to 60°F during periods when the diesel is not operating.

9.4.7.2 System Description

9.4.7.2.1 General Description

Figure 9.4-7 is the piping and instrumentation diagram for the DGB ventilation and heating system.

The DGB ventilation system provides cooling for the diesel generators, using outside air as the cooling medium. Air is supplied into the building, pressurizing the building slightly, and is vented from the building through exhaust air louver openings. Each diesel generator room is provided with a separate system. Electric unit heaters are provided in each room for heating.

The ventilation system serves as a source of makeup air which is used for combustion air by the diesel.

Provisions have been made in the diesel generator building design, electrical starting system, and combustion air and ventilation air intake design to preclude the accumulation of dust and other deleterious material on electrical equipment associated with starting of the diesel generators to ensure availability of the diesel generator on demand. All electrical equipment mounted outside of the control panels for the diesel generator unit are provided with either NEMA 4 or NEMA 12 enclosures. The control panels themselves are of NEMA 12 construction with filtered ventilation openings. The DGB ventilation system employs no filters and thus supplies outside air directly to the building. However, the system will operate primarily only when the diesel generator is operating and, therefore, minimizes the time during which it will operate. The ventilation system intake is located on top of the DGB and, therefore, will intake only those particulates which are airborne (no ground dust).

9.4.7.2.2 Component Description

Codes and standards applicable to the DGB ventilation system are listed in Tables 3.2-1 and 9.4-14. The DGB ventilation system is designed and constructed in accordance with codes and standards comparable with quality group C.

SAFETY-RELATED FANS - The DGB supply fan is located in each diesel generator room. These fans are vaneaxial fans with electric motor drivers.

UNIT HEATERS - Heating of the diesel generator building is provided by electric unit heaters. Each unit heater consists of a coil and a fan with an electric motor driver.

ISOLATION DAMPERS - Where a means of system isolation is required, parallel-blade-type dampers are utilized. The type of operator employed is dependent upon the specific design and/or usage requirements.

FLOW CONTROL DAMPERS - Opposed-blade-type dampers are utilized, as necessary, to provide a means of system balancing. In general, these are manually operated. However, some utilize power operators to allow compensation for changes occurring during system operation.

TORNADO DAMPERS - Tornado dampers are employed where isolation from the effects of extreme wind or tornado conditions is required. These dampers close with the flow produced by the differential pressure associated with the tornado or high winds.

9.4.7.2.3 System Operation

The DGB ventilation system is automatically activated at a temperature no higher than 112°F. The ventilation system can be manually activated, if necessary, to provide cooling during occupation of the building. Operation of the diesel building HVAC is not interlocked with the diesel engine controls. A failure of, or spurious signal from, the HVAC will not prevent starting of the diesel engine or shutdown of the engine once it is operating. When the ventilation system is in operation, the supply fans take suction from the outside air and supply air directly to their respective diesel generator room for maximum cooling requirements. However, each system is provided with a recirculation mode, whereby a portion of the room air may be mixed with the outside air. This recirculation mode is primarily for winter operation to prevent freezing. The recirculated room air is utilized for tempering the outside air. Outside air intake and exhaust louvers are selected on the basis of adverse environmental conditions. Louver blades are fixed and, hence, cannot become inoperable due to freezing or icing. They are designed to reduce cascading and reentrainment of water into the airstream. Design of the louvers is for air inlet velocities below 500 fpm to prevent moisture carryover. Electrical unit heaters are provided in each room to limit the minimum room temperature to 60°F when the diesels are not operating. These unit heaters operate automatically and independently from the ventilation system.

The fire protection system provided for the diesel generators is a preaction sprinkler system. Carbon dioxide is not utilized as the extinguishing medium. Hence, there is no possibility of CO_2 being drawn into the combustion air. The exhaust stack is located approximately 65 feet horizontally from the air intake and discharges approximately 35 feet above the air intake. The exhaust stack is located approximately 31 feet from the air exhaust louvers and also discharges approximately 35 feet above the air exhaust louvers. The distances between the diesel intake and exhaust, the exit velocity of the gases from the exhaust stack, and the buoyancy of the hot exhaust gases are sufficient to reduce the possibility of exhaust gases being drawn into the combustion air stream to insignificant levels.

The probability of inducing exhaust gases into the intake air stream, due to the loss of the stacks, is slight since the distance between the intake and exhaust (65 feet) is sufficient to prevent a short-circuiting of the exhaust gases. For the case where the combustion air source is through the ventilation exhaust louvers, the probability of inducing exhaust gases, due to the loss of one of the stacks, is slight since the distance (31 feet) is sufficient to prevent short circuiting of exhaust gases. Also, it is unlikely that the ventilation exhaust louvers would be the only source of combustion air since the exhaust air flowpath is a backup source for combustion air as described in the “Emergency Operations” section.

Discussed below are the emergency operations of the DGB ventilation system. Except for operation of the unit heaters, the power generation operations and shutdown operations are identical to the emergency operations.

EMERGENCY OPERATIONS - The DGB ventilation system is automatically activated at a temperature no higher than 112°F. The ventilation system can be manually activated, if necessary, to provide cooling during occupation of the building.

For maximum cooling, the supply fans take suction from the outside and supply directly to their respective rooms. All cooling is accomplished by the outside air. The size of the intake and exhaust louvers is based on the maximum required quantity of cooling air, 120,000 cfm. Each fan is provided with a mixing box arrangement. When maximum cooling is not required, a portion of the room air is mixed with the outside air. The proportion of outside air and room air is controlled by a room thermostat to maintain the ambient temperature within its specified range, when outside temperatures permit. This mixing mode is primarily for winter operation to prevent freezing and to minimize cycling of the fans. The room air is utilized for tempering the outside air.

The supply air system serves as a source of makeup for combustion air to be used by the diesel generators and introduces a minimum of 30,000 cfm of outside air during the recirculation mode. (The maximum quantity of air required by the diesel for combustion is 24,000 cfm.) The exhaust air flowpath has provisions for serving as the backup source of combustion air. The exhaust flowpath is provided with a damper which is designed to fail in the open position. The exhaust damper is normally closed when the ventilation system is not operating, to prevent cold outside air from entering the building. This

exhaust damper opens automatically upon a diesel start to assure a source of combustion air, regardless of the mode of operation of the supply air system.

The diesel room is pressurized slightly by the air supply system and relieved through the exhaust louver. The exhaust damper, located upstream of the exhaust louver and tornado damper, will provide building isolation against outside air infiltration during system shutdown.

The diesel generators building supply air system intake and the exhaust system ductwork contain dampers capable of withstanding the effects of extreme wind or tornado conditions (3 psi in one and one-half seconds per Regulatory Guide 1.76). These dampers close with the flow produced by the differential pressure associated with the high winds or tornado. The damper located in the exhaust system ductwork is spring loaded to prevent closure during normal system operation.

Missile barriers are provided externally to the isolation system to prevent damage by a tornado missile.

Both the supply air intake and the recirculation ductwork are provided with modulating dampers operated by electrohydraulic actuators. These dampers modulate, as required, to provide the required mixing of the supply and recirculation air to maintain the room temperature within the specified limits. Modulation of the dampers is controlled by a Class 1E control circuit which senses the room temperature and operates the dampers accordingly. This control circuit serves to automatically start the fan prior to the room temperature exceeding 112°F, as well as initiate opening of the exhaust damper. This control circuit also serves to alarm the control room, via the plant computer, of low room temperature and high room temperature.

The ventilation system with its recirculation mode of operation, whenever the diesels are operating, can maintain room ambient temperatures between 40 and 122°F when the outside ambient temperatures are between (-)1 and 97°F. When the diesels are in standby, heating is provided by strategically located unit heaters.

Electrical unit heaters, each individually controlled by its associated room thermostat, are provided in each room to limit the minimum room temperature to 60°F during periods when the diesel is not operating. These unit heaters operate automatically and independently from the ventilation system. The unit heaters are energized when the room temperature reaches 60°F (minimum) and cut off when the temperature reaches 65°F (maximum).

9.4.7.3 Safety Evaluation

Safety evaluations are numbered to correspond to the safety design bases in Section 9.4.7.1.

SAFETY EVALUATION ONE - The safety-related portions of the DGB ventilation system are located in the diesel building, which is designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other appropriate natural phenomena. Sections 3.3, 3.4, 3.5, 3.7(B), and 3.8 provide the bases for the adequacy of the structural design of these buildings.

SAFETY EVALUATION TWO - The safety-related portions of the DGB ventilation system are designed to remain functional after a SSE. Sections 3.7(B).2 and 3.9(B) provide the design loading conditions that were considered. Sections 3.5, 3.6, and 9.5.1 provide the hazards analyses to assure that a safe shutdown, as outlined in Section 7.4 can be achieved and maintained.

SAFETY EVALUATION THREE - Complete redundancy is provided for the DGB, ventilation system and, as indicated by Table 9.4-15, no single failure will compromise the system's safety functions. All vital power can be supplied from either onsite or offsite power systems, as described in Chapter 8.0.

SAFETY EVALUATION FOUR - The DGB ventilation system is initially tested with the program given in Chapter 14.0. Periodic inservice functional testing is done in accordance with Section 9.4.7.4.

SAFETY EVALUATION FIVE - Section 3.2 delineates the quality group classification and seismic category applicable to the safety-related portion of this system and supporting system. All the power supplies and control functions necessary for safe function of the DGB ventilation system as Class 1E, as described in Chapters 7.0 and 8.0.

SAFETY EVALUATION SIX - The DGB ventilation system has sufficient cooling capability to maintain the diesel room at 122°F or below with the diesel operating at rated load and with ambient outside air temperature of 97°F. The DGB ventilation system is automatically activated at a temperature no higher than 112°F.

9.4.7.4 Tests and Inspections

Preoperational testing is described in Chapter 14.0.

One of the two redundant DGB fans is tested in accordance with standards of the Air Moving and Conditioning Association (AMCA) to assure fan characteristic performance curves.

Major components are accessible during normal plant operation for inspection, maintenance, and periodic testing.

9.4.7.5 Instrumentation Applications

Indication of the DGB fan operational status is provided in the control room.

All DGB fans are operable from the control room.

An indication of the position of all exhaust dampers is provided in the control room.

Thermostats control the room temperatures.

The DGB room temperature is available in the control room.

High and low DGB room temperature is alarmed in the control room.

Exhaust dampers are operable from the control room.

9.4.8 ESSENTIAL SERVICE WATER PUMPHOUSE VENTILATION

The function of the essential service water (ESW) pumphouse ventilation system is to provide an environment suitable for operation of the essential service water pump motors and associated electrical equipment.

A ventilation subsystem, physically independent from the ESW pumphouse ventilation system, is provided for the ultimate heat sink (UHS) electrical equipment rooms. This system functions to provide an environment suitable for operation of the electrical equipment associated with the UHS cooling tower fans.

9.4.8.1 Design Bases

9.4.8.1.1 Safety Design Bases

The ESW pumphouse ventilation system and the UHS electrical equipment room ventilation system, excluding unit heaters, are safety related, are required to function following a DBA, and are required to achieve and maintain the plant in a safe shutdown condition.

SAFETY DESIGN BASIS ONE - The ESW pumphouse ventilation system and the UHS electrical equipment room ventilation system are protected from the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, and external missiles (GDC-2).

SAFETY DESIGN BASIS TWO - The ESW pumphouse ventilation system and the UHS electrical equipment room ventilation system remain functional after an SSE and perform their intended function following a postulated hazard, such as a fire, internal missiles, or pipe break (GDC-3 and 4).

SAFETY DESIGN BASIS THREE - Safety functions can be performed, assuming a single active component failure coincident with the loss of offsite power (GDC-44).

SAFETY DESIGN BASIS FOUR - Active components of the ESW pumphouse ventilation system and the UHS electrical equipment room ventilation system are capable of being tested during plant operation.

SAFETY DESIGN BASIS FIVE - The ESW pumphouse ventilation system and the UHS electrical equipment room ventilation system use the design and fabrication codes consistent with the quality group classification assigned by Regulatory Guide 1.26 and the seismic category assigned by Regulatory Guide 1.29. The power supply and control functions must be in accordance with Regulatory Guide 1.32.

SAFETY DESIGN BASIS SIX - The ESW pumphouse ventilation system and the UHS electrical equipment room ventilation system are designed to limit the building to a maximum ambient temperature of 122°F (50°C). Cooling is accomplished by the outside air.

9.4.8.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - The essential service water pumphouse heating system will limit the minimum room temperature to 50°F during periods when the pumps are not operating.

POWER GENERATION DESIGN BASIS TWO - The ultimate heat sink electrical equipment room heating system will limit the minimum room temperature to 50°F during periods when the cooling tower fans are not operating.

9.4.8.2 System Description

9.4.8.2.1 General Description

The ESW pumphouse ventilation system and the UHS electrical equipment room ventilation system are shown in Figure 9.4-8.

The ESW pumphouse ventilation system provides cooling for the essential service water pump motors, using outside air as the cooling medium. Air is supplied into the building, pressurizing the building slightly, and is vented from the building through exhaust air louver openings. Each ESW pumproom is provided with a separate system. Electric unit heaters are provided in each room for heating.

The UHS electric equipment room ventilation system provides cooling for the associated electrical equipment for the cooling tower fans, using outside air as the cooling medium. Air is supplied into the building, pressurizing the building slightly, and is vented from the building through screened openings provided under the eaves. Each UHS electric room is provided with a separate system. Electric unit heaters are provided in each room for heating.

9.4.8.2.2 Component Description

Codes and Standards applicable to the ESW pumphouse ventilation system and the UHS electrical equipment room ventilation system are listed in Tables 3.2-1 and 9.4-16. The ventilation systems, excluding unit heaters, are designed and constructed in accordance with codes and standards comparable with quality group C. The unit heaters are designed and constructed in accordance with codes and standards comparable with quality group D.

SAFETY-RELATED FANS - An ESW pumphouse supply fan is located in each pumproom. These fans are vaneaxial fans with electric motor operators. The UHS electrical equipment room supply fans are centrifugal fans with electric motor drives.

UNIT HEATERS - Heating of the ESW pumphouse and the UHS electrical equipment rooms is provided by electric unit heaters.

TORNADO DAMPERS - Tornado dampers are provided in the ventilation intake and exhaust paths. These dampers close with the flow produced by the differential pressure associated with high winds or tornadoes.

ISOLATION DAMPERS - The ventilation exhaust paths employ air-operated, parallel-blade-type dampers for isolation.

FLOW CONTROL DAMPERS - The ventilation supply systems employ opposed-blade-type dampers as the means for controling the mixture of recirculation and outside air being supplied to the pumproom. These dampers are operated by means of electro/ hydraulic actuators.

9.4.8.2.3 System Operation

Each ESW pumphouse ventilation subsystem is automatically actuated by a start of the associated essential service water pump. The supply fans take suction from the outside and supply air directly to the respective pumprooms.

The UHS electrical equipment room ventilation system is automatically actuated by a start of the associated cooling tower fans. The supply fans take suction from the outside and supply air directly to the respective electrical equipment rooms.

However, when maximum cooling is not required, each system is provided with a recirculation mode whereby a portion of the room air is mixed with the outside air. This recirculation mode is primarily for winter operation to prevent freezing and continuous cycling of the fans. The recirculated room air is utilized for tempering the outside air.

Each room is provided with dampers in the supply and exhaust ductwork to isolate the outside openings during a tornado.

Electric unit heaters are provided in each room to limit the minimum room temperature to 50°F. These unit heaters operate automatically and independently of the ventilation system.

Discussed below are the emergency operations only, since there are no power generation operations associated with the ESW pumphouse ventilation system.

EMERGENCY OPERATIONS - The ESW pumphouse ventilation system is automatically activated upon starting the associated ESW pump and can be manually shut down when the pump shuts down. The UHS electric equipment room ventilation system is automatically activated upon starting of the associated cooling tower fans and automatically shut down when the cooling tower fans shut down. During periods when the pumps or fans are shut down, the ventilation system can be manually activated to provide cooling, if necessary, during occupation of the building. Each subsystem may be started manually, either by the local handswitch located in the room, or by the remote handswitch located in the control room.

For maximum cooling, the supply fans take suction from the outside and supply directly to their respective rooms. All cooling is accomplished by outside air. Each fan is provided with a mixing box arrangement. When maximum cooling is not required, a portion of the room air is mixed with the outside air. The proportion of outside air to room air is controlled by a room thermostat to maintain ambient temperature within a specified range. This mixing mode is primarily for winter operation to prevent freezing and to minimize cycling of the fans. The room air is used for tempering the outside air.

The exhaust flow path is provided with a damper which is designed to fail in the open position. The exhaust damper is normally closed, when the pumps or cooling tower fans are not operating, to prevent cold outside air from entering the building. This exhaust damper opens automatically upon initiation of pump or fan operation to assure an exhaust air flow path, regardless of the mode of operation of the supply air system.

The ESW pumphouse and the UHS electrical equipment rooms are pressurized slightly by the air supply system and relieved through the exhaust system. The exhaust damper, located upstream of the exhaust louver and tornado damper, will provide building isolation against outside air infiltration during system shutdown.

The supply air system intake and the exhaust system ductwork contain dampers capable of withstanding the effects of extreme wind or tornado conditions (a differential pressure of 3 psi and a differential pressure rate of 2 psi per second per Regulatory Guide 1.76). These dampers close with the flow produced by the differential pressure associated with the high winds or tornado. The damper located in the exhaust system ductwork is spring loaded to prevent closure during normal system operation.

Missile barriers are provided externally to the isolation system to prevent damage by a tornado missile.

Both the supply air intake and the recirculation ductwork are provided with modulating dampers operated by electrohydraulic actuators. The dampers modulate, as required, to provide the required mixing of the supply and recirculation air to maintain the room temperature within the specified limits. Modulation of the dampers is controlled by a Class 1E control circuit which senses the room temperature and operates the dampers accordingly. This control circuit also serves to alarm the control room, via the plant computer, of low room temperature and high room temperature and to shut down the fan should the room temperature fall below 60°F.

The ventilation system with its recirculation mode of operation, whenever the pumps or cooling tower fans are operating, can maintain room ambient temperatures between 50 and 122°F when the outside ambient temperatures are between the minimum and maximum site design temperatures (see Table 9.4-16).

When the pumps or cooling tower fans, and hence ventilation system, are in standby, heating is provided by strategically located unit heaters. Electric unit heaters, each individually controlled by its associated room thermostat, are provided in each room to limit the minimum room temperature to 50°F. These unit heaters are nonseismic Category I, and operate automatically and independently from the ventilation system. The unit heaters are energized when the room temperature falls below 50°F and cut off when the temperature rises above this setpoint including tolerances.

9.4.8.3 Safety Evaluation

Safety evaluations are numbered to correspond to the safety design bases in Section 9.4.8.1.

SAFETY EVALUATION ONE - The safety-related portions of the ESW pumphouse ventilation system and the UHS electrical equipment room ventilation system are located in the ESW pumphouse and the UHS electrical equipment room, both of which are designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other appropriate natural phenomena. Sections 3.3, 3.4, 3.5, 3.7(B), and 3.8 provide the bases for the adequacy of the structural design of these buildings.

SAFETY EVALUATION TWO - The safety-related portions of the ESW pumphouse and UHS electrical equipment room ventilation systems are designed to remain functional after SSE. Sections 3.7(B).2 and 3.9(B) provide the design loading conditions that were considered. Sections 3.5, 3.6, and 9.5.1 provide the hazards analyses to assure that a safe shutdown, as outlined in Section 7.4 can be achieved and maintained.

SAFETY EVALUATION THREE - The system description shows that complete redundancy of the ESW pumphouse and the UHS electrical equipment room ventilation systems is provided and, as indicated by Table 9.4-17, no single failure will compromise the system's safety functions. All vital power can be supplied from either onsite or offsite power systems, as described in Chapter 8.0.

SAFETY EVALUATION FOUR - The ESW pumphouse and the UHS electrical equipment room ventilation systems are initially tested with the program given in Chapter 14.0. Periodic inservice functional testing is done in accordance with Section 9.4.8.4.

SAFETY EVALUATION FIVE - Section 3.2 delineates the quality group classification and seismic category applicable to the safety-related portion of this system and supporting system. All the power supplies and control functions necessary for safe function of the ESW pumphouse and the UHS electrical equipment room ventilation systems are Class 1E, as described in Chapters 7.0 and 8.0.

SAFETY EVALUATION SIX - The ESW pumphouse and the UHS electrical equipment room ventilation systems have sufficient cooling capacity to maintain the room at 122°F or below when the ESW pump motors or the cooling tower fans, respectively, are operating at rated load and the outside air is at the maximum site design ambient.

9.4.8.4 Tests and Inspections

Preoperational testing is described in Chapter 14.0.

One of each group of ESW pumphouse ventilation fans and the UHS electrical equipment room ventilation fans are tested in accordance with standards of the Air Moving and Conditioning Association (AMCA) to ensure fan characteristic performance curves.

Major components are accessible during normal plant operation for inspection, maintenance, and periodic testing.

9.4.8.5 Instrumentation Applications

Indication of ESW pumphouse and the UHS electrical equipment room fan operational status is provided in the control room.

All ESW pumphouse and UHS electrical equipment room fans are operable from the control room.

Thermostats control the room temperatures.

Each room's temperature is available in the control room.

High and low room temperature is alarmed in the control room.

9.4.9 PLANT HEATING SYSTEM

The plant heating system (PHS) serves as the heating medium for air to provide a suitable environment for personnel and equipment.

9.4.9.1 Design Bases

9.4.9.1.1 Safety Design Basis

This system serves no safety function. Failure of the system does not affect safe shutdown of the plant.

9.4.9.1.2 Power Generation Design Basis

POWER GENERATION DESIGN BASIS ONE - The PHS provides hot water for the heating coils and the unit heaters.

9.4.9.2 System Description

9.4.9.2.1 General Description

The PHS is shown in Figure 9.4-9.

The PHS is composed of redundant hot-water pumps, a steam-to-water heat exchanger, and a supply and return piping system. Each of the hot-water pumps is rated at 100 percent of the total system flow to ensure system operation in the event of the failure of one of the pumps. An expansion tank is provided on the suction side of the hot-water pumps to accommodate the volume of water expansion and maintain suction pressure for the pumps.

The steam-to-water heat exchanger is located on the discharge side of the hot-water pumps and heats the water flowing through it. During normal plant operation, the heat exchanger utilizes steam from the reboiler as the heating medium, and during plant shutdown it utilizes steam produced by the auxiliary boiler.

To prevent rusting and deterioration of the piping, corrosion inhibitors are introduced on the suction side of the hot-water pumps.

In-line, secondary loop, hot-water pumps are provided with the heating coils for all outside supply air units.

9.4.9.2.2 Component Description

Codes and standards applicable to the PHS are listed in Table 9.4-18. The plant heating system is designed and constructed in accordance with codes and standards comparable with quality group D.

The PHS consists of a steam-to-water heat exchanger, two 100-percent-capacity pumps, electric motor drivers, expansion tank, and associated piping, valves, instruments, and controls.

HEAT EXCHANGER - The plant heating heat exchanger is the steam-to-water type and consists of a shell and tubes. The steam is supplied to the shell, and the water to be heated flows through the tubes.

PUMPS - The main hot-water pumps are the centrifugal vertical split case type with electric motor drivers.

Design data for the plant heating system components are given in Table 9.4-18.

9.4.9.2.3 System Operation

The heating system, which utilizes hot water as the heating medium, provides the source of heat for the ventilation system heating coils and unit heaters. The hot water is pumped by one of the two hot-water pumps through the supply main to the heat exchanger, where its temperature is raised to 198°F. The 198°F water then flows to the various heating coils where the air is heated. It then leaves the coils at approximately 158°F and flows through the return main to the hot-water pumps.

Operation of the hot-water pumps is initiated either manually by operator action or automatically upon indication of low outside air temperature. Temperature sensors are located outside the auxiliary and control buildings near the air intakes. Either sensor will automatically initiate the hot-water pumps and energize the inlet steam temperature control valve. The pumps will start with an outside air temperature of approximately 60°F, or less.

Overpressure protection is provided for both the shell and tube sides of the plant heating heat exchanger.

9.4.9.3 Safety Evaluation

The operation of the PHS is not required for the safe shutdown of the plant or for mitigating the consequences of a design basis accident.

9.4.9.4 Tests and Inspections

Preoperational testing is described in Chapter 14.0.

The hot-water system is hydrostatically tested in accordance with ANSI B31.1.

Major components are accessible during normal plant operation for inspection, maintenance, and periodic testing.

9.4.9.5 Instrumentation Applications

An alarm is provided in the control room to indicate high and low water levels in the expansion tank.

Local pressure indication is provided upstream and downstream of each hot-water pump.

9.4.10 CENTRAL CHILLED WATER SYSTEM

The central chilled water system (CeCWS) serves as the cooling medium for equipment to provide a suitable environment for personnel and equipment and to reduce the outside air requirements.

9.4.10.1 Design Bases

9.4.10.1.1 Safety Design Basis

The CeCWS serves no safety function. Failure of the system does not affect the safe shutdown of the plant.

9.4.10.1.2 Power Generation Design Basis

POWER GENERATION DESIGN BASIS ONE - The CeCWS provides chilled water for the cooling coils.

9.4.10.2 System Description

9.4.10.2.1 General Description

The CeCWS is shown on Figure 9.4-10.

The CeCWS provides the cooling medium, when required, for equipment and ventilation system cooling coils. The CeCWS is composed of redundant chilled-water pumps and chillers and a supply and return piping system. Each of the chilled-water pumps is rated at 100 percent of the total system load, as are the chillers, to ensure system operation in the event of the failure of one of the components. A nitrogen blanketed expansion tank is provided on the suction side of the chilled-water pumps to accommodate the volume of water expansion and maintain suction pressure for the pumps.

The chillers are located on the discharge side of the chilled-water pumps and cool the water flowing through them. The service water system serves as the heat sink for the chillers.

The CeCWS operates in a closed loop mode. To prevent rusting and deterioration of the piping, chilled water is demineralized and corrosion inhibitors are introduced on the suction side of the pumps. Strainers are placed in the line at the inlet to the pumps to protect the equipment.

9.4.10.2.2 Component Description

Codes and standards applicable to the CeCWS are listed in Table 9.4-19. The central chilled water system is designed and constructed in accordance with codes and standard comparable with quality group D.

The CeCWS consists of two 100-percent-capacity chillers, two 100-percent-capacity pumps, electric motor drivers, an expansion tank, and the associated piping, valves, instruments, and controls.

CENTRAL CHILLERS - The central chillers are the centrifugal type, and each chiller consists of a compressor, an evaporator, and a water-cooled condenser.

PUMPS - The chilled-water pumps are the centrifugal type with electric motor drivers.

Design data for components of the CeCWS are given in Table 9.4-19.

9.4.10.2.3 System Operation

The CeCWS provides the cooling medium for the ventilation cooling coils all year around, except for the winter shutdown period.

Operation of the chilled-water pumps and chillers is manually initiated from a local control panel. The chillers and the chilled-water pumps are arranged in parallel. This permits manual alignment, so that either chilled-water pump may service either chiller.

During system operation, the chilled water is pumped by one of the two chilled-water pumps through the supply main to the chiller, where its temperature is lowered to approximately 44°F. The 44°F water then flows to the various cooling zones, where it absorbs heat from the air passing over the coils. Water leaves the coils at approximately 62°F and flows through the return main to the chilled-water pumps. The heat absorbed at the coils is transferred to the chiller, which, in turn, rejects this heat to the service water.

Fully automatic condenser water flow control is provided to regulate the water flow rate to maintain the condenser head pressure. This arrangement serves as a means of head pressure control to maintain chiller operation within the more efficient range and to preclude tripping.

A means of adjusting chiller capacity in proportion to the variation in the design load is obtained through the use of temperature control. This is accomplished by means of variable inlet guide vanes at the suction to the compressor. This control reduces the capacity of the chiller by varying the angle at which the suction gas is directed into the eye of the impeller. A chilled-water temperature sensor, located in the main header downstream of the pumps, automatically maintains the leaving chilled-water temperature at 44°F.

When the temperature changes, the temperature sensor signals the chilled-water temperature controller to reposition the capacity-regulating vanes, which change the capacity of the chiller to maintain the desired temperature. When the vanes reach the closed position and the leaving temperature of the chilled water continues to decrease to the predetermined minimum, approximately 40°F, the low chilled-water temperature cut-out switch stops the compressor.

9.4.10.3 Safety Evaluation

The operation of the CeCWS is not required for the safe shutdown of the plant or for mitigating the consequences of a design basis accident.

9.4.10.4 Tests and Inspections

Preoperational testing is described in Chapter 14.0.

Major components are accessible during normal plant operation for inspection, maintenance, and periodic testing.

9.4.10.5 Instrumentation Applications

An alarm is provided in the control room to indicate high and low water levels in the expansion tank.

Local differential pressure indication is provided across each strainer upstream of the pumps, and local pressure indication is provided downstream of each pump.

A temperature sensor located in the main header downstream of the pumps is provided to control the leaving chilled-water temperature.

A low chilled-water temperature cut-out switch stops the chiller.

TABLE 9.4-1 OUTSIDE ENVIRONMENT DESIGN CONDITIONS

	Summer		Winter	
	Dry Bulb (F)	Wet Bulb (F)	Dry Bulb (F)	Wind Velocity (mph)
Normal Design Conditions (See Note 1)	97	79	(-)25*	15
Extreme Design Conditions (See Note 2)	120	__	(-)60	__

NOTES:

1. The outdoor ambient summer temperatures are taken from the 1972 ASHRAE Handbook of Fundamentals, Weather Data and Design Conditions, Chapter 33, Table 1. Summer 97-1/2 percent (worst site) and 99 percent (all others) values are used. The outdoor ambient winter temperature is based on the requirements of the Wisconsin Administrative Code. The winter wind velocity was assumed for conservatism.

2. All safety-related HVAC systems and components which are exposed to the outside environment are capable of sustaining the SNUPPS extreme temperature conditions without loss of function (see Section 3.11). However, no HVAC system (safety-related or nonsafety-related) is designed to maintain space design temperatures while operating during the SNUPPS extreme temperature conditions.

* With the exception of the diesel generator rooms and the emergency fuel oil storage tank access vaults. These areas were evaluated at (-)1°F. This temperature is taken from the ASHRAE Handbook, 1977 Fundamentals, Winter 99% Design Dry Bulb for Columbia, MO.

TABLE 9.4-2 DESIGN COMPARISON TO REGULATORY POSITIONS OF REGULATORY GUIDE 1.52, REVISION 2, DATED MARCH 1978, TITLED "DESIGN, TESTING AND MAINTENANCE CRITERIA FOR POST-ACCIDENT ENGINEERED-SAFETY-FEATURE ATMOSPHERE CLEANUP SYSTEM AIR FILTRATION AND ADSORPTION UNITS OF LIGHT-WATER-COOLED NUCLEAR POWER PLANTS."

Design requirements of this Regulatory Guide are applicable to the following standardized power plant exhaust systems:

a. Emergency exhaust

b. Control room filtration

c. Control room pressurization

Design requirements for nonsafety-related normal exhaust systems are discussed in Table 9.4-3.

Regulatory Guide 1.52 Position	Union Electric*
1. Environmental Design Criteria	1. Environmental Design Criteria
a. The design of an engineered-safety-feature atmosphere cleanup system should be based on the maximum pressure differential, radiation dose rate, relative humidity, maximum and minimum temperature, and other conditions resulting from the postulated DBA and on the duration of such conditions.	a. Complies.
b. The design of each ESF system should be based on the radiation dose to essential services in the vicinity of the adsorber section, integrated over the 30-day period following the postulated DBA. The radiation source term should be consistent with the assumptions found in Regulatory Guides 1.3 (Ref. 5), 1.4 (Ref. 6) and 1.25 (Ref. 7). Other engineered safety features, including pertinent components of essential services such as power, air, and control cables should be adequately shielded from the ESF atmosphere cleanup systems.	b. Complies.

TABLE 9.4-2 (Sheet 2)

Regulatory Guide 1.52 Position	Union Electric*
c. The design of each adsorber should be based on the concentration and relative abundance of the iodine species (elemental, particulate, and organic), which should be consistent with the assumptions found in Regulatory Guides 1.3 (Ref. 5), 1.4 (Ref. 6), and 1.25 (Ref. 7).	c. Complies.
d. The operation of any ESF atmosphere cleanup system should not deleteriously affect the operation of other engineered safety features such as a containment spray system, nor should the operation of other engineered safety features such as a containment spray system deleteriously affect the operation of any ESF atmosphere cleanup system.	d. Complies.
e. Components of systems connected to compartments that are unheated during a postulated accident should be designed for post-accident effects of both the lowest and highest predicted temperatures.	e. Complies.

TABLE 9.4-2 (Sheet 3)

Regulatory Guide 1.52 Position	Union Electric*
2. System Design Criteria	2. System Design Criteria
a. ESF atmosphere cleanup systems designed and installed for the purpose of mitigating accident doses should be redundant. The systems should consist of the following sequential components: (1) demisters, (2) prefilters (demisters may serve this function), (3) HEPA filters before the adsorbers, (4) iodine adsorbers (impregnated activated carbon or equivalent adsorbent such as metal zeolites), (5) HEPA filters after the adsorbers, (6) ducts and valves, (7) fans, and (8) related instrumentation. Heaters or cooling coils used in conjunction with heaters should be used when the humidity is to be controlled before filtration.	a.1. Control room pressurization system complies. a.2. Emergency exhaust system complies, except that demisters are not provided. Water droplets will not be entrained in the airstream. a.3. Control room filtration system complies, except that demisters are not provided. Water droplets will not be entrained in the airstream. Humidity control is provided by safety-related air-conditioning system which has provisions for dehumidifying.
b. The redundant ESF atmosphere cleanup systems should be physically separated so that damage to one system does not also cause damage to the second system. The generation of missiles from high-pressure equipment rupture, rotating machinery failure, or natural phenomena should be considered in the design for separation and protection.	b. Complies.
c. All components of an engineered-safety-feature atmosphere cleanup system should be designated as Seismic Category I (see Regulatory Guide 1.29 (Ref. 8)) if failure of a component would lead to the release of significant quantities of fission products to the working or outdoor environments.	c. Complies.

TABLE 9.4-2 (Sheet 4)

Regulatory Guide 1.52 Position	Union Electric*
d. If the ESF atmosphere cleanup system is subject to pressure surges resulting from the postulated accident, the system should be protected from such surges. Each component should be protected with such devices as pressure relief valves so that the overall system will perform its intended function during and after the passage of the pressure surge.	d. Not applicable. The systems are located outside of the containment and not exposed to pressure surges.
e. In the mechanical design of the ESF system, the high radiation levels that may be associated with buildup of radioactive materials on the ESF system components should be given particular consideration. ESF system construction materials should effectively perform their intended function under the postulated radiation levels. The effects of radiation should be considered not only for the demisters, heaters, HEPA filters, adsorbers, and fans, but also for any electrical insulation, controls, joining compounds, dampers, gaskets, and other organic-containing materials that are necessary for operation during a postulated DBA.	e. Complies.
f. The volumetric air flow rate of a single clean-up train should be limited to approximately 30,000 ft^3/min. If a total system air flow in excess of this rate is required, multiple trains should be used. For ease of maintenance, a filter layout three HEPA filters high and ten wide is preferred.	f. Complies.
g. The ESF atmosphere cleanup system should be instrumented to signal, alarm, and record pertinent pressure drops and flow rates at the control room.	g. Complies, except that flow rates are not recorded. High and low differential pressure computer alarms in the control room provide indication of any abnormality in flow rates.

TABLE 9.4-2 (Sheet 5)

Regulatory Guide 1.52 Position	Union Electric*
h. The power supply and electrical distribution system for the ESF atmosphere cleanup system described in Section C.2.a above should be designed in accordance with Regulatory Guide 1.32 (Ref. 9). All instrumentation and equipment controls should be designed to IEEE Standard 279 (Ref. 10). The ESF system should be qualified and tested under Regulatory Guide 1.89 (Ref. 11). To the extent applicable, Regulatory Guides 1.30 (Ref. 12), 1.100 (Ref. 13), and 1.118 (Ref. 14) and IEEE Standard 334 (Ref. 15) should be considered in the design.	h. Complies.
i. Unless the applicable engineered-safety-feature atmosphere cleanup system operates continuously during all times that a DBA can be postulated to occur, the system should be automatically activated upon the occurrence of a DBA by (1) a redundant engineered-safety-feature signal (i.e., temperature, pressure) or (2) a signal from redundant Seismic Category I radiation monitors.	i. Complies.
j. To maintain radiation exposures to operating personnel as low as is reasonably achievable during plant maintenance, ESF atmosphere cleanup systems should be designed to control leakage and facilitate maintenance in accordance with the guidelines of Regulatory Guide 8.8 (Ref. 16). The ESF atmosphere cleanup train should be totally enclosed. Each train should be designed and installed in a manner that permits replacement of the train as an intact unit or as a minimum number of segmented sections without removal of individual components.	j. Complies.

TABLE 9.4-2 (Sheet 6)

Regulatory Guide 1.52 Position	Union Electric*
k. Outdoor air intake openings should be equipped with louvers, grills, screens, or similar protective devices to minimize the effects of high winds, rain, snow, ice, trash, and other contaminants on the operation of the system. If the atmosphere surrounding the plant could contain significant environmental contaminants, such as dusts and residues from smoke cleanup systems from adjacent coal burning power plants or industry, the design of the system should consider these contaminants and prevent them from affecting the operation of any ESF atmosphere cleanup system.	k. Complies.
l. ESF atmosphere cleanup system housings and ductwork should be designed to exhibit on test a maximum total leakage rate as defined in Section 4.12 of ANSI N509-1976 (Ref. 1). Duct and housing leak tests should be performed in accordance with the provisions of Section 6 of ANSI N510-1975 (Ref. 2).	l. Complies.
3. Component Design Criteria and Qualification Testing	3. Component Design Criteria and Qualification Testing
a. Demisters should be designed, constructed, and tested in accordance with the requirements of Section 5.4 of ANSI N509-1976 (Ref. 1). Demisters should meet Underwriters' Laboratories (UL) Class 1 (Ref. 17) requirements.	a.1. Not applicable to emergency exhaust and control room filtration system. See response to Regulatory Position 2.a above. a.2. Control room pressurization system complies.

TABLE 9.4-2 (Sheet 7)

Regulatory Guide 1.52 Position	Union Electric*
b. Air heaters should be designed, constructed, and tested in accordance with the requirements of Section 5.5 of ANSI N509-1976 (Ref. 1).	b.1. Not applicable to control room filtration system. See response to Regulatory Position 2.a above. b.2. Control room pressurization system and emergency exhaust system comply, except that the reset function for the charcoal adsorber train heater stage air overtemperature cutout switch is automatic. Overtemperature cutoff switches that must be manually reset are not recommended based on the 1989 edition of ANSI N509. In addition, the overtemperature cutoff switch setpoint is not 225 degrees (Fahrenheit) as recommended, but heater design calculations demonstrate that the air temperature should not exceed 225 degrees (Fahrenheit).
c. Materials used in the prefilters should withstand the radiation levels and environmental conditions prevalent during the postulated DBA. Prefilters should be designed, constructed, and tested in accordance with the provisions of Section 5.3 of ANSI N509-1976 (Ref. 1).	c. Complies, except that prefilters should be designed, constructed, and tested in accordance with Article FB of ASME-AG-1 1997, and no prefilters are used for control room pressurization system.

TABLE 9.4-2 (Sheet 8)

Regulatory Guide 1.52 Position	Union Electric*
d. The HEPA filters should be designed, constructed, and tested in accordance with Section 5.1 of ANSI N509-1976 (Ref. 1).[1] Each HEPA filter should be tested for penetration of dioctyl phthalate (DOP) in accordance with the provisions of MIL-F-51068 (Ref. 19) and MIL-STD-282 (Ref. 20).[2]	d. Complies.
e. Filter and adsorber mounting frames should be constructed and designed in accordance with the provisions of Section 5.6.3 of ANSI N509-1976 (Ref. 1).	e. Complies, except frames are tightened to produce acceptable bypass leakage results.
f. Filter and adsorber banks should be arranged in accordance with the recommendations of Section 4.4 of ERDA 76-21 (Ref. 3).	f. Complies.
g. System filter housings, including floors and doors, should be constructed and designed in accordance with the provisions of Section 5.6 of ANSI N509-1976 (Ref. 1).	g. Complies.
h. Water drains should be designed in accordance with the recommendations of Section 4.5.8 of ERDA 76-21 (Ref. 3).	h. Complies, except each filter section is equipped with a threaded pipe cap to provide for draining capability, in lieu of drain piping with traps and Chicago fittings. This is sufficient in light of the fact that fire water spray is manually initiated and controlled.

TABLE 9.4-2 (Sheet 9)

Regulatory Guide 1.52 Position	Union Electric*
i. The adsorber section of the ESF atmosphere cleanup system may contain any adsorbent material demonstrated to remove gaseous iodine (elemental iodine and organic iodides) from air at the required efficiency. Since impregnated activated carbon is commonly used, only this adsorbent is discussed in this guide. Each original or replacement batch of impregnated activated carbon used in the adsorber section should meet the qualification and batch test results summarized in Table 5.1 of ANSI N509-1976 (Ref. 1). In this table, a "qualification test" should be interpreted to mean a test that establishes the suitability of a product for a general application, normally a one-time test reflecting historical typical performance of material. In this table, a "batch test" should be interpreted to mean a test made on a production batch of product to establish suitability for a specific application. A "batch of activated carbon" should be interpreted to mean a quantity of material of the same grade, type, and series that has been homogenized to exhibit, within reasonable tolerance, the same performance and physical characteristics and for which the manufacturer can demonstrate by acceptable tests and quality control practices such uniformity.	i. Complies, except that new activated charcoal adsorber is procured to meet the physical properties of the 1980 version of ANSI/ASME N509 Table 5-1 and the performance requirements of ASTM D3803-1989.

TABLE 9.4-2 (Sheet 10)

Regulatory Guide 1.52 Position	Union Electric*
All material in the same batch should be activated, impregnated, and otherwise treated under the same process conditions and procedures in the same process equipment and should be produced under the same manufacturing release and instructions. Material produced in the same charge of batch equipment constitutes a batch; material produced in different charges of the same batch equipment should be included in the same batch only if it can be homogenized as above. The maximum batch size should be 350 ft^3 of activated carbon.	
If an adsorbent other than impregnated activated carbon is proposed or if the mesh size distribution is different from the specifications in Table 5.1 of ANSI N509-1976 (Ref. 1), the proposed adsorbent should have demonstrated the capability to perform as well as or better than activated carbon in satisfying the specifications in Table 5.1 of ANSI N509-1976 (Ref. 1).	
If impregnated activated carbon is used as the adsorbent, the adsorber system should be designed for an average atmosphere residence time of 0.25 sec per two inches of adsorbent bed.	
The adsorption unit should be designed for a maximum loading of 2.5 mg of total iodine (radioactive plus stable) per gram of activated carbon. No more than 5% of impregnant (50 mg of impregnant per gram of carbon) should be used. The radiation stability of the type of carbon specified should be demonstrated and certified (see Section C.1.b of this guide for the design source term).	

TABLE 9.4-2 (Sheet 11)

Regulatory Guide 1.52 Position	Union Electric*
j. Adsorber cells should be designed, constructed, and tested in accordance with the requirements of Section 5.2 of ANSI N509-1976 (Ref. 1).	j. Complies.
k. The design of the adsorber section should consider possible iodine desorption and adsorbent auto-ignition that may result from radioactivity-induced heat in the adsorbent and concomitant temperature rise. Acceptable designs include a low-flow air bleed system, cooling coils, water sprays for the adsorber section, or other cooling mechanisms. Any cooling mechanism should satisfy the single-failure criterion. A low-flow air bleed system should satisfy the single-failure criterion for providing low-humidity (less than 70% relative humidity) cooling air flow.	k.1. Emergency exhaust system charcoal bed temperature will be maintained below desorption range by assuring a minimum air flow across the loaded bed (complies with ANSI N509-1976). Also manually actuated water sprays are provided, if required to prevent or mitigate ignition.
	k.2. Control room filtration and control room pressurization systems comply. Anticipated charcoal bed loading is not sufficient to raise bed temperature to the desorption range. However, manually actuated water sprays are provided, if required to prevent or mitigate ignition.
l. The system fan, its mounting, and the ductwork connections should be designed, constructed, and tested in accordance with the requirements of Sections 5.7 and 5.8 of ANSI N509-1976 (Ref. 1).	l. Complies.
m. The fan or blower used on the ESF atmosphere cleanup system should be capable of operating under the environmental conditions postulated, including radiation.	m. Complies.

TABLE 9.4-2 (Sheet 12)

Regulatory Guide 1.52 Position	Union Electric*
n. Ductwork should be designed, constructed, and tested in accordance with the provisions of Section 5.10 of ANSI N509-1976 (Ref. 1).	n. Complies.
o. Ducts and housings should be laid out with a minimum of ledges, protrusions, and crevices that could collect dust and moisture and that could impede personnel or create a hazard to them in the performance of their work. Straightening vanes should be installed where required to ensure representative air flow measurement and uniform flow distribution through cleanup components.	o. Complies.
p. Dampers should be designed, constructed, and tested in accordance with the provisions of Section 5.9 of ANSI N509-1976 (Ref. 1).	p. Complies. Dampers are designed, constructed, and tested in accordance with codes and standards comparable with the provisions of Section 5.9 of ANSI N509-1976.
4. Maintenance	4. Maintenance
a. Accessibility of components and maintenance should be considered in the design of ESF atmosphere cleanup systems in accordance with the provisions of Section 2.3.8 of ERDA 76-21 (Ref. 3) and Section 4.7 of ANSI N509-1976 (Ref. 1).	a. Complies.
b. For ease of maintenance, the system design should provide for a minimum of three feet from mounting frame to mounting frame between banks of components. If components are to be replaced, the dimension to be provided should be the maximum length of the component plus a minimum of three feet.	b. Complies where internal removal of components is required.

TABLE 9.4-2 (Sheet 13)

Regulatory Guide 1.52 Position	Union Electric*
c. The system design should provide for permanent test probes with external connections in accordance with the provisions of Section 4.11 of ANSI N509-1976 (Ref. 1).	c. Does not comply, filtration unit is not equipped with permanent test probes/ manifolds to facilitate in-place testing. Injection and sampling methods have been verified as required by ANSI N509-1976.

TABLE 9.4-2 (Sheet 14)

Regulatory Guide 1.52 Position	Union Electric*
d. Each ESF atmosphere cleanup train should be operated at least 10 hours per month, with the heaters on (if so equipped), in order to reduce the buildup of moisture on the adsorbers and HEPA filters.	d. Regulatory position C.b.1 of Regulatory Guide 1.52 Revision 3 directs that each ESF atmosphere cleanup train be operated at least 15 minutes per month with heaters on (if so equipped.) In accordance with the applicable Surveillance Requirements in the Technical Specifications, the frequency for performing periodic ESF atmosphere cleanup train runs is controlled in accordance with the Surveillance Frequency Control Program. Accordingly, each control room emergency ventillation system train pressurization filter unit and each emergency exhaust system train filter unit is periodically operated for at least 15 minutes with the heaters on. Each control room emergency ventillation system train filtration unit (no heater) is periodically operated for at least 15 minutes.
e. The cleanup components (i.e., HEPA filters, prefilters, and adsorbers) should not be installed while active construction is still in progress.	e. Complies.
5. In-Place Testing Criteria	5. In-Place Testing Criteria

TABLE 9.4-2 (Sheet 15)

Regulatory Guide 1.52 Position	Union Electric*
a. A visual inspection of the ESF atmosphere cleanup system and all associated components should be made before each in-place airflow distribution test, DOP test, or activated carbon adsorber section leak test in accordance with the provisions of Section 5 of ANSI N510-1975 (Ref. 2).	a. Complies.
b. The airflow distribution to the HEPA filters and iodine adsorbers should be tested in place for uniformity initially and after maintenance affecting the flow distribution. The distribution should be within ±20% of the average flow per unit. The testing should be conducted in accordance with the provisions of Section 9 of "Industrial Ventilation" (Ref. 21) and Section 8 of ANSI N510-1975 (Ref. 2).	b. Complies, except that testing conducted in accordance with ANSI N510 will utilize the 1980 edition in lieu of the 1975 edition. However, air flow distribution testing will be performed only on the downstream side of the first HEPA filters in lieu of each filter as stated in Section 8.1 of ANSI N510-1980. Prerequisite flow testing in accordance with Section 8 will be performed at design differential pressure.

TABLE 9.4-2 (Sheet 16)

Regulatory Guide 1.52 Position	Union Electric*
c. The in-place DOP test for HEPA filters should conform to Section 10 of ANSI N510-1975 (Ref. 2). HEPA filter sections should be tested in place (1) initially, (2) at least once per 18 months thereafter, and (3) following painting, fire, or chemical release in any ventilation zone communicating with the system to confirm a penetration of less than 0.05% at rated flow. An engineered-safety-feature air filtration system satisfying this condition can be considered to warrant a 99% removal efficiency for particulates in accident dose evaluations. HEPA filters that fail to satisfy this condition would be replaced with filters qualified pursuant to regulatory position C.3.d of this guide. If the HEPA filter bank is entirely or only partially replaced, an in-place DOP test should be conducted. If any welding repairs are necessary on, within, or adjacent to the ducts, housing, or mounting frames, the filters and adsorbers should be removed from the housing during such repairs. The repairs should be completed prior to periodic testing, filter inspection, and in-place testing. The use of silicone sealants or any other temporary patching material on filters, housing, mounting frames, or ducts should not be allowed.	c. Complies, except that the Technical Specification acceptance criteria of less than 1.0 percent in-place penetration and bypass leakage shall be employed. The Technical Specification requirements, although less stringent than the Reg. Guide, still allow a conservative design, as the accident dose evaluation assumes a 95 percent efficiency for the GK system and 90% for the GG system. The in-place DOP testing will be performed in accordance with Section 10 of ANSI N510-1975, but the prerequisite testing in Sections 8 and 9 will be performed in accordance with the 1980 version in lieu of the 1975 version. Air/aerosol mixing is not performed on the downstream banks. Challenge of the downstream banks is performed by removing filters from the upstream bank.

TABLE 9.4-2 (Sheet 17)

Regulatory Guide 1.52 Position	Union Electric*
d. The activated carbon adsorber section should be leak tested with a gaseous halogenated hydrocarbon refrigerant in accordance with Section 12 of ANSI N510-1975 (Ref. 2) to ensure that bypass leakage through the adsorber section is less than 0.05%. After the test is completed, air flow through the unit should be maintained until the residual refrigerant gas in the effluent is less than 0.01 ppm. Adsorber leak testing should be conducted (1) initially, (2) at least once per 18 months thereafter, (3) following removal of an adsorber sample for laboratory testing if the integrity of the adsorber section is affected, and (4) following painting, fire, or chemical release in any ventilation zone communicating with the system.	d. Complies, except that the Technical Specification acceptance criteria of less than 1.0 percent in-place penetration and bypass leakage shall be employed. The Technical Specification requirements, although less stringent than the Reg. Guide, still allow a conservative design, as the accident dose evaluation assumes a 95 percent efficiency for all forms of iodine for the control building pressurization and control building filtration filter adsorber units (GK system). An efficiency of 90% is assumed for the auxiliary/fuel building emergency exhaust system filter adsorber units (GG system) for all forms of iodine in the ECCS leakage dose pathway. The in-place adsorber testing will be performed in accordance with Section 12 of ANSI N510-1975, but the prerequisite testing in Sections 8 and 9 will be performed in accordance with the 1980 version in lieu of the 1975 version. Air/aerosol mixing is not performed on the downstream banks.

TABLE 9.4-2 (Sheet 18)

Regulatory Guide 1.52 Position	Union Electric*
	Challenge of the downstream banks is performed by removing filters from the upstream bank.
6. Laboratory Testing Criteria for Activated Carbon	6. Laboratory Testing Criteria for Activated Carbon
a. The activated carbon adsorber section of the ESF atmosphere cleanup system should be assigned the decontamination efficiencies given in Table 2 for elemental iodine and organic iodides if the following conditions are met:	a.1. See the discussion of Regulatory Position C.5.d above. a.2. See the discussion of Regulatory Position C.3.i above.
(1) The adsorber section meets the conditions given in regulatory position C.5.d of this guide.	a.3. Used activated charcoal adsorber samples are laboratory tested per ASTM D3803-1989 as required by the Ventilation Filter Testing Program requirements of Technical Specification 5.5.11.c.
(2) New activated carbon meets the physical property specifications given in Table 5.1 of ANSI N509-1976 (Ref. 1), and	
(3) Representative samples of used activated carbon pass the laboratory tests given in Table 2.	
If the activated carbon fails to meet any of the above conditions, it should not be used in engineered-safety-feature adsorbers.	

TABLE 9.4-2 (Sheet 19)

Regulatory Guide 1.52 Position	Union Electric*
b. The efficiency of the activated carbon adsorber section should be determined by laboratory testing of representative samples of the activated carbon exposed simultaneously to the same service conditions as the adsorber section. Each representative sample should be not less than two inches in both length and diameter, and each sample should have the same qualification and batch test characteristics as the system adsorbent. There should be a sufficient number of representative samples located in parallel with the adsorber section to estimate the amount of penetration of the system adsorbent throughout its service life. The design of the samplers should be in accordance with the provisions of Appendix A of ANSI N509-1976 (Ref. 1). Where the system activated carbon is greater than two inches deep, each representative sampling station should consist of enough two-inch samples in series to equal the thickness of the system adsorbent. Once representative samples are removed for laboratory test, their positions in the sampling array should be blocked off. Laboratory tests of representative samples should be conducted, as indicated in Table 2 of this guide, with the test gas flow in the same direction as the flow during service conditions. Similar laboratory tests should be performed on an adsorbent sample before loading into the adsorbers to establish an initial point for comparison of future test results. The activated carbon adsorber section should be replaced with new unused activated carbon meeting the physical property specifications of Table 5.1 of ANSI N509-1976 (Ref. 1) if (1) testing in accordance with the frequency specified in Footnote c of Table 2 results in a representative sample failing to pass the applicable test in Table 2 or (2) no representative sample is available for testing.	b. Complies, except that representative samples are tested per the requirements of ASTM D3803-1989, not Table 2 of the Regulatory Guide. See the discussion of Regulatory Position C.6.a(3) above.

TABLE 9.4-2 (Sheet 20)

1 The pertinent quality assurance requirements of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50 apply to all activities affecting the safety-related functions of HEPA filters.

2 The U.S. Department of Energy (USDOE) operates a number of filter test facilities qualified to perform HEPA filter efficiency tests. These facilities are listed in the current USDOE Environmental Safety and Health Information Bulletin for Filter Unit Inspection and Testing Service (Ref. 18).

* All statements apply to all three exhaust systems listed above, unless otherwise indicated.

TABLE 9.4-3 DESIGN COMPARISON TO REGULATORY POSITIONS OF REGULATORY GUIDE 1.140, REVISION 1, DATED OCTOBER 1979, TITLED "DESIGN, TESTING, AND MAINTENANCE CRITERIA FOR NORMAL VENTILATION EXHAUST SYSTEM AIR FILTRATION AND ADSORPTION UNITS OF LIGHT-WATER-COOLED NUCLEAR POWER PLANTS."

Design requirements of this Regulatory Guide are applicable to the following standardized power plant exhaust systems:

a. Condenser air removal filtration

b. Radwaste building exhaust

c. Access control exhaust

d. Containment purge

e. Auxiliary/fuel building normal exhaust

f. LDF dryer exhaust HEPA filter**

Design requirements for safety-related exhaust systems are discussed in Table 9.4-2.

Regulatory Guide 1.140 Position	Union Electric*
1. Environmental Design Criteria	1. Environmental Design Criteria
a. The design of each atmosphere cleanup system installed in a normal ventilation exhaust system should be based on the maximum anticipated operating parameters of temperature, pressure, relative humidity, and radiation levels.	a. Complies.
b. If the atmosphere cleanup system is located in an area of high radiation during normal plant operation, adequate shielding of components and personnel from the radiation source should be provided.	b. Complies.
c. The operation of any atmosphere cleanup system in a normal ventilation exhaust system should not deleteriously affect the expected operation of any engineered-safety-feature system that must operate after a design basis accident.	c. Complies.

TABLE 9.4-3 (Sheet 2)

Regulatory Guide 1.140 Position	Union Electric*
d. The design of the atmosphere cleanup system should consider any significant contaminants such as dusts, chemicals, or other particulate matter that could deleteriously affect the cleanup system's operation.	d. Complies.
2. System Design Criteria	2. System Design Criteria
a. Atmosphere cleanup systems installed in normal ventilation exhaust systems need not be redundant nor designed to seismic Category I classification, but should consist of the following sequential components: (1) HEPA filters before the adsorbers, (2) iodine adsorbers (impregnated activated carbon or equivalent adsorbent such as metal zeolites), (3) fans and, (4) interspersed ducts, dampers, and related instrumentation. If it is desired to reduce the particulate load on the HEPA filters and extend their service life, the installation of prefilters upstream of the initial HEPA bank is suggested. Consideration should also be given to the installation of a HEPA filter bank downstream of carbon adsorbers to retain carbon fines. Heaters or cooling coils used in conjunction with heaters should be used when the humidity is to be controlled before filtration. Whenever an atmosphere cleanup system is designed to remove only particulate matter, a component for iodine adsorption need not be included.	a. Complies. Heaters or cooling coils are not required.
b. To ensure reliable in-place testing, the volumetric air flow rate of a single cleanup train should be limited to approximately 30,000 ft^3/min. If a total system air flow in excess of this rate is required, multiple trains should be used. For ease of maintenance, a filter layout that is three HEPA filters high and ten wide is preferred.	b. Complies, except that air flow rate for auxiliary/fuel building normal exhaust is 32,000 cfm (multiple trains are not used due to space limitation).

TABLE 9.4-3 (Sheet 3)

Regulatory Guide 1.140 Position	Union Electric*
c. Each atmosphere cleanup system should be instrumented to monitor and alarm pertinent pressure drops and flow rates in accordance with the recommendations of Section 5.6 of ERDA 76-21 (Ref. 3).	c. Complies. A differential pressure indicator controller modulates a damper located across the filtration unit downstream of the filter train to maintain a constant system resistance as the filters load up. This arrangement assures a constant system flow. High and low differential pressure alarms provide indication of any abnormality in flow rates.
d. To maintain the radiation exposure to operating and maintenance personnel as low as is reasonably achievable, atmosphere cleanup systems and components should be designed to control leakage and facilitate maintenance, inspection, and testing in accordance with the guidelines of Regulatory Guide 8.8, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable" (Ref. 5).	d. Complies.
e. Outdoor air intake openings should be equipped with louvers, grills, screens, or similar protective devices to minimize the effects of high winds, rain, snow, ice, trash, and other contaminants on the operation of the system. If the atmosphere surrounding the plant could contain significant environmental contaminants, such as dusts and residues from smoke cleanup systems from adjacent coal burning power plants or industry, the design of the system should consider these contaminants and prevent them from affecting the operation of any atmosphere cleanup system.	e. Complies.

TABLE 9.4-3 (Sheet 4)

Regulatory Guide 1.140 Position	Union Electric*
f. Atmosphere cleanup system housings and ductwork, as defined in section 5.10.8.1 of ANSI N509-1976 (Ref. 1), should be designed to exhibit on test a maximum total leakage rate as defined in Section 4.12 of ANSI N509-1976 (Ref. 1). Duct and housing leak tests should be performed in accordance with the provisions of Section 6 of ANSI N510-1975 (Ref. 2).	f. Complies.
3. Component Design Criteria and Qualification Testing	3. Component Design Criteria and Qualification Testing
a. Adsorption units function efficiently at a relative humidity of 70% or less. If the relative humidity of the atmosphere entering the air cleanup system is expected to be greater than 70% during normal reactor operation, heaters or cooling coils used in conjunction with heaters should be designed to reduce the relative humidity of the entering atmosphere to 70% or less. Heaters should be designed, constructed, and tested in accordance with the requirements of Section 5.5 of ANSI N509-1976 (Ref. 1) exclusive of sizing criteria.	a. Not applicable to these systems. See response to Regulatory Position 2.a. above.
b. The HEPA filters should be designed, constructed, and tested in accordance with the requirements of Section 5.1 of ANSI N509-1976 (Ref. 1). Each HEPA filter should be tested for penetration of dioctyl phthalate (DOP) in accordance with the provisions of MIL-F-51068 (Ref. 6) and MIL-STD-282 (Ref. 7).	b. Complies, except the downstream HEPA filter bank will not be tested for penetration with DOP.
c. Filter and adsorber mounting frames should be designed and constructed in accordance with the provisions of Section 5.6.3 of ANSI N509-1976 (Ref. 1).	c. Complies.

TABLE 9.4-3 (Sheet 5)

Regulatory Guide 1.140 Position	Union Electric*
d. Filter and adsorber banks should be arranged in accordance with the recommendations of Section 4.4 of ERDA 76-21 (Ref. 3).	d. Complies.
e. System filter housings, including floors and doors, and electrical conduits, drains, and piping installed inside filter housings should be designed and constructed in accordance with the provisions of Section 5.6 of ANSI N509-1976 (Ref. 1).	e. Complies.
f. Ductwork associated with the atmosphere cleanup system should be designed, constructed, and tested in accordance with the provisions of Section 5.10 of ANSI N509-1976 (Ref. 1).	f. Complies.
g. The adsorber section of the atmosphere cleanup system may contain any adsorbent material demonstrated to remove gaseous iodine (elemental iodine and organic iodides) from air at the required efficiency. Since impregnated activated carbon is commonly used, only this adsorbent is discussed in this guide. Each original or replacement batch of impregnated activated carbon used in the adsorber section should meet the qualification and batch test results summarized in Table 1 of this guide. If an adsorbent other than impregnated activated carbon is proposed or if the mesh size distribution is different from the specifications in Table 1, the proposed adsorbent should have demonstrated the capability to perform as well as or better than activated carbon in satisfying the specifications in Table 1. If impregnated activated carbon is used as the adsorbent, the adsorber system should be designed for an average atmosphere residence time of 0.25 sec per two inches of adsorbent bed.	g. Complies, except that new activated charcoal adsorber is procured to meet the physical properties of the 1980 version of ANSI/ASME N509 Table 5-1 and the performance requirements of ASTM D3803-1989.

TABLE 9.4-3 (Sheet 6)

Regulatory Guide 1.140 Position	Union Electric*
h. Adsorber cells should be designed, constructed, and tested in accordance with the requirements of Section 5.2 of ANSI N509-1976 (Ref. 1).	h. Complies.
i. The system fan and motors, mounting, and ductwork connections should be designed, constructed, and tested in accordance with the requirements of Sections 5.7 and 5.8 of ANSI N509-1976 (Ref. 1).	i. Complies.
j. The fan and motor used in the atmosphere cleanup system should be capable of operating under the environmental conditions postulated.	j. Complies.
k. Ducts and housings should be laid out with a minimum of ledges, protrusions, and crevices that could collect dust and moisture and that could impede personnel or create a hazard to them in the performance of their work. Turning vanes or other airflow distribution devices should be installed where required to ensure representative air flow measurement and uniform flow distribution through cleanup components.	k. Complies.
l. Dampers should be designed, constructed, and tested in accordance with the provisions of Section 5.9 of ANSI N509-1976 (Ref. 1).	l. Complies. Dampers are designed, constructed, and tested in accordance with codes and standards comparable with the provisions of Section 5.9 of ANSI N509-1976.
m. If prefilters are used in the atmosphere cleanup system, they should be designed, constructed, and tested in accordance with the provisions of Section 5.3 of ANSI N509-1976 (Ref. 1).	m. If prefilters are used in the atmospheric cleanup system, they should be designed, constructed, and tested in accordance with Article FB of ASME-AG-1 1997.
4. Maintenance	4. Maintenance

TABLE 9.4-3 (Sheet 7)

Regulatory Guide 1.140 Position	Union Electric*
a. Accessibility of components and maintenance should be considered in the design of atmosphere cleanup systems in accordance with the provisions of Section 2.3.8 of ERDA 76-21 (Ref. 3) and Section 4.7 of ANSI N509-1976 (Ref. 1).	a. Complies.
b. For ease of inspection and maintenance with minimum danger of damage to the system, its design should provide for a minimum of three feet clear access space in each compartment after allowing for the component dimension itself and the maximum length of the component during changeout.	b. Complies where internal removal of components is required.
c. The system design should provide for permanent test probes with external connections in accordance with the provisions of Section 4.11 of ANSI N509-1976 (Ref. 1).	c. Does not comply, filtration unit is not equipped with permanent test probes/manifolds to facilitate in-place testing. Injection and sampling methods have been verified as required by ANSI N509-1976.
d. The cleanup components (e.g., HEPA filters and adsorbers) should be installed after construction is completed.	d. Complies.
5. In-Place Testing Criteria	5. In-Place Testing Criteria
a. A visual inspection in accordance with the provisions of Section 5 of ANSI N510-1975 (Ref. 2), of the atmosphere cleanup system and all associated components should be made before each in-place airflow distribution test, DOP test, or activated carbon adsorber section leak test.	a. Complies.

TABLE 9.4-3 (Sheet 8)

Regulatory Guide 1.140 Position	Union Electric*
b. The airflow distribution to the HEPA filters and iodine adsorbers should be tested in-place for uniformity initially and after maintenance affecting the flow distribution. The distribution should be within ± 20% of the average flow per unit when tested in accordance with the provisions of Section 9 of "Industrial Ventilation" (Ref. 8) and Section 8 of ANSI N510-1975 (Ref. 2).	b. Complies, except that testing conducted in accordance with ANSI N510 will utilize the 1980 edition in lieu of the 1975 edition. However, air flow distribution testing will be performed only on the downstream side of the first HEPA filters in lieu of each filter as stated in Section 8.1 of ANSI N510-1980. Airflow capacity testing is performed at design differential pressure.

TABLE 9.4-3 (Sheet 9)

Regulatory Guide 1.140 Position	Union Electric*
c. The in-place DOP test for HEPA filters should conform to Section 10 of ANSI N510-1975 (Ref. 2). HEPA filter sections should be tested in place initially and at intervals of approximately 18 months thereafter. The HEPA filter bank upstream of the adsorber section should also be tested following painting, fire, or chemical release in any ventilation zone communicating with the system in such a manner that the HEPA filters could become contaminated from the fumes, chemicals, or foreign materials. DOP penetration tests of all HEPA filter banks should confirm a penetration of less than 0.05% at rated flow. A filtration system satisfying this condition can be considered to warrant a 99% removal efficiency for particulates. HEPA filters that fail to satisfy the in-place test criteria should be replaced with filters qualified pursuant to regulatory position C.3.b of this guide. If the HEPA filter bank is entirely or only partially replaced, in-place DOP test should be conducted. If any welding repairs are necessary on, within, or adjacent to the ducts, housing, or mounting frames, the filters and adsorbers should be removed from the housing during such repairs. These repairs should be completed prior to periodic testing, filter inspection, and in-place testing. The use of silicone sealants or any other temporary patching material on filters, housing, mounting frames, or ducts should not be allowed.	c. Complies, except that an acceptance criteria of less than 1.0 percent in-place penetration and bypass leakage shall be employed to be consistent with the acceptance criteria utilized for the engineered safety-feature filtration units. This requirement, although less stringent than the required .05 percent, still allows a conservative design, as the filter efficiency is assumed to be 95 percent in accident analyses. The in-place DOP testing will be performed in accordance with Section 10 of ANSI N510-1975, but prerequisite testing in Sections 8 and 9 will be performed in accordance with ANSI N510-1980. The downstream HEPA filter banks will not be tested for DOP penetration. They will however be visually inspected in accordance with section 5 of ANSI N510-1975 (Ref. 2).

TABLE 9.4-3 (Sheet 10)

Regulatory Guide 1.140 Position	Union Electric*
d. The activated carbon adsorber section should be leak-tested with a gaseous halogenated hydrocarbon refrigerant in accordance with Section 12 of ANSI N510-1975 (Ref. 2) to ensure that bypass leakage through the adsorber section is less than 0.05%. After the test is completed, air flow through the unit should be maintained until the residual refrigerant gas in the effluent is less than 0.01 ppm. Adsorber leak testing should be conducted (1) initially, (2) at intervals of approximately 18 months thereafter, (3) following removal of an adsorber sample for laboratory testing if the integrity of the adsorber section is affected, and (4) following painting, fire, or chemical release in any ventilation zone communicating with the system in such a manner that the charcoal adsorbers could become contaminated from the fumes, chemicals, or foreign materials.	d. Complies, except that an acceptance criteria of less than 1.0 percent in-place penetration and bypass leakage shall be employed to be consistent with the acceptance criteria utilized for the engineered safety-feature filtration units. This requirement, although less stringent than the required .05 percent, still allows a conservative design, as the filter efficiency is assumed to be 95 percent in accident analyses. The in-place testing will be performed in accordance with Section 12 of ANSI N510-1975, but the prerequisite testing in Sections 8 and 9 will be performed in accordance with the 1980 version in lieu of the 1975 version. Air/aerosol mixing is not performed on the adsorber bank. Challenge of the downstream banks is demonstrated by adequate mixing on the upstream HEPA bank.
6. Laboratory Testing Criteria for Activated Carbon	6. Laboratory Testing Criteria for Activated Carbon
a. The activated carbon adsorber section of the atmosphere cleanup system should be assigned the decontamination efficiencies given in Table 2 for radioiodine if the following conditions are met:	a. Complies, except that new activated charcoal adsorber is procured to meet the physical properties of the 1980 version of ANSI/ASME N509 Table 5-1 and the performance requirements of ASTM D3803-1989.

TABLE 9.4-3 (Sheet 11)

Regulatory Guide 1.140 Position	Union Electric*
(1) The adsorber section meets the conditions given in regulatory position C.5.d of this guide, (2) New activated carbon meets the physical property specifications given in Table 1, and (3) Representative samples of used activated carbon pass the laboratory tests given in Table 2. If the activated carbon fails to meet any of the above conditions, it should not be used in adsorption units.	
b. The efficiency of the activated carbon adsorber section should be determined by laboratory testing of representative samples of the activated carbon exposed simultaneously to the same service conditions as the adsorber section. Each representative sample should be not less than two inches in both length and diameter, and each sample should have the same qualification and batch test characteristics as the system adsorbent. There should be a sufficient number of representative samples located in parallel with the adsorber section to estimate the amount of penetration of the system adsorbent throughout its service life. The design of the samplers should be in accordance with the provisions of Appendix A of ANSI N509-1976 (Ref. 1). Where the system activated carbon is greater than two inches deep, each representative sampling station should consist of enough two-inch samples in series to equal the thickness of the system adsorbent. Once representative samples are removed for laboratory test, their positions in the sampling array should be clocked off.	b. Complies, except that new activated charcoal adsorber is procured to meet the physical properties of the 1980 version of ANSI/ASME N509 Table 5-1 and the performance requirements of ASTM D3803-1989.

TABLE 9.4-3 (Sheet 12)

Regulatory Guide 1.140 Position	Union Electric*
Laboratory tests of representative samples should be conducted, as indicated in Table 2 of this guide, with the test gas flow in the same direction as the flow during service conditions. Similar laboratory tests should be performed on an adsorbent sample before loading into the adsorbers to establish an initial point for comparison of future test results. The activated carbon adsorber section should be replaced with new unused activated carbon meeting the physical property specifications of Table 1 if (1) testing in accordance with the frequency specified in Footnote c of Table 2 results in a representative sample failing to pass the applicable test in Table 2 or (2) no representative sample is available for testing.	

*All statements apply to all exhaust systems listed above, unless otherwise indicated.

**This unit is significantly different than the other units addressed in this table refer to the attachment for RFR 19598A for complete comparison of this unit with Reg. Guide 1.140.

TABLE 9.4-4 DESIGN DATA FOR CONTROL BUILDING HVAC SYSTEM COMPONENTS*

I. Control Building Supply System	
A. Supply Air Unit	
Quantity	1
Air flow, cfm	15,000
Static pressure, in. w.g.	5.39
Motor horsepower, hp	25
Total cooling capacity, Btu/hr	1,114,000
Total heating capacity, Btu/hr	1,479,000
Chilled water flow, gpm	131
Hot water flow, gpm	73
Design codes and standards	
Unit	MS
Motor	NEMA
Coil	MS
Seismic design	Non-Category I
B. Control Room Electric Duct Heater	
Quantity	1
Heater rating, kW	35
Design standards	MS
Seismic design	Non-Category I
C. Access Control Supply System Booster Coil	
Quantity	1
Heater rating, kW	7
Design standards	MS
Seismic design	Non-Category I
D. Access Control Supply System Booster Coil	
Quantity	1
Heater rating, kW	8
Design standards	MS
Seismic design	Non-Category I
II. Control Building Exhaust System	
Quantity	2
Type	Vaneaxial
Air flow, cfm each	8,900
Total pressure, in. w.g.	4.09
Motor horsepower, hp	10

TABLE 9.4-4 (Sheet 2)

	Design codes and standards	
	Fan	MS
	Motor	NEMA
	Seismic design	Non-Category I
III.	Access Control Exhaust System	
	A. Adsorber Train	
	Quantity	1
	Particulate filters	4
	HEPA filters	8
	Charcoal, lbs	1,070 (approx.)
	Design criterion (unit)	Reg. Guide 1.140
	Seismic design	Non-Category I
	B. Fans	
	Quantity	2
	Type	Centrifugal
	Air flow, cfm each	6,000
	Static pressure, in. w.g.	9.40
	Motor horsepower, hp	15
	Design codes and standards	
	Fan	MS
	Motor	NEMA
	Seismic design	Non-Category I
IV.	Control Room Air-Conditioning System	
	A. Control Room Air-Conditioning Unit	
	Quantity	2
	Flow, cfm each	18,000
	Static pressure, in. w.g.	3.0
	Motor horsepower, hp	40
	Total cooling capacity, Btu/hr each	480,946
	Compressor power input, kW	48.6
	Condenser water flow, gpm each	140
	Fouling factor (service water)	.002
	Design codes and standards	
	Unit	IEEE-323 and 344
	Condenser	ASME Section III, Class 3
	Seismic design	Category I
	B. Control Room Filtration System Adsorber Train	
	Quantity	2
	Particulate filters, each	2

TABLE 9.4-4 (Sheet 3)

HEPA filters, each	4
Charcoal, lbs. each	270 (approx.)
Design criterion	Reg. Guide 1.52
Seismic design	Category I
C. Control Room Filtration Fan	
Quantity	2
Air flow, cfm each	2,000
Static pressure, in. w.g.	6.80
Motor horsepower, hp	5.0
Design codes and standards	
Fan	MS
Motor	IEEE-323
Seismic design	Category I
D. Control Room Pressurization System Adsorber Train	
Quantity	2
Demisters, each	1
HEPA filters, each	2
Charcoal, lbs. each	135 (approx.)
Electric heater, quantity each	1
Heater rating, kW each	15
Design codes and standards	
Unit	Reg. Guide 1.52
Heater	IEEE-323
Seismic design	Category I
E. Control Room Pressurization System Fan	
Quantity	2
Air flow, cfm each	2,200
Static pressure, in. w.g.	8.5
Motor horsepower, hp	7.5
Design codes and standards	
Fan	MS
Motor	IEEE-323
Seismic design	Category I
V. Class 1E Electrical Equipment Air-Conditioning System	
Quantity	2
Flow, cfm each	11,500
Static pressure, in. w.g.	3.50
Motor horsepower, hp	15.0
Total cooling capacity, Btu/hr each	370,200

TABLE 9.4-4 (Sheet 4)

Compressor power input, kW	36.3
Condenser water flow, gpm each	66
Fouling factor (service water)	.002
Design codes and standards	
Unit	IEEE-323 and 344
Condenser	ASME Section III, Class 3
Seismic design	Category I
VI. Access Control Air-Conditioning System	
A. Access Control Fan Coil Unit	
Quantity	1
Air flow, cfm	5,000
Static pressure, in. w.g.	4.93
Motor horsepower, hp	7.50
Total cooling capacity, Btu/hr	150,000
Fouling factor (chilled water)	0.0005
Chilled water flow, gpm	18
Design codes and standards	
Unit	MS
Motor	NEMA
Coil	MS
Seismic design	Non-Category I
B. Access Control Air-Conditioning System Booster Coil	
Quantity	1
Heating rating, kW	16
Design standards	MS
Seismic design	Non-Category I
C. Mechanical Equipment Room Booster Coil	
Quantity	2
Heater rating, kW each	6
Design standards	MS
Seismic design	Non-Category I
VII. Unit Heaters	
A. Upper Cable Spreading Room Unit Heater	
Quantity	2
Type	Electric
Heater rating, kW each	40
Design standards	MS
Seismic design	Non-Category I

TABLE 9.4-4 (Sheet 5)

B. Lower Cable Spreading Room Unit Heater	
Quantity	2
Type	Electric
Heater rating, kW each	10
Design standards	MS
Seismic design	Non-Category I
C. ESF Switchgear Room Unit Heater	
Quantity	2
Type	Electric
Heater rating, kW each	7.5
Design standards	MS
Seismic design	Non-Category I
D. Pipe Chase and Tank Area Unit Heater	
Quantity	3
Type	Electric
Heater rating, kW each	5
Design standards	MS
Seismic design	Non-Category I
E. Control Room Air-Conditioning Equipment Room Unit Heater	
Quantity	1
Type	Electric
Heater rating, kW	25
Design standards	MS
Seismic design	Non-Category I
F. Control Room Air-Conditioning Equipment Room Unit Heater	
Quantity	1
Type	Electric
Heater rating, kW	15
Design standards	MS
Seismic design	Non-Category I
VIII. Counting Room Recirculation System	
A. Counting Room Fan Coil Unit	
Quantity	1
Air flow, cfm	1,500
Static pressure, in. w.g.	6.8
Motor horsepower, hp	5.0
Total cooling capacity, Btu/hr	36,500
Chilled water flow, gpm	4
Humidifier water flow, gpm	0.5

TABLE 9.4-4 (Sheet 6)

Design codes and standards	
Unit	MS
Motor	NEMA
Coil	MS
Seismic Design	Non-Category I
B. Counting Room Filter Unit	
Quantity	1
Particulate filters	1
HEPA filters	1
Design codes and standards (unit)	MS
Seismic design	Non-Category I
C. Counting Room Cooling Coil	
Quantity	1
Total cooling capacity, Btu/hr	47,000
Chilled water flow, gpm	5
Design codes and standards	
Coil	MS
Seismic design	Non-Category I
D. Counting Room Backup Cooling Coil	
Quantity	1
Total cooling capacity, Btu/hr	33,700
Type	Direct Expansion
Refrigerant	R-22
Design codes and standards	
Coil	MS
Condenser	MS
Seismic design	Non-Category I

* NOTE: Design parameters shown in Table 9.4-4 represent the values specified in procurement specifications. Minor variations in performance characteristics may exist between individual components. Adequate margin is maintained to ensure components can perform their design function.

TABLE 9.4-5 SINGLE FAILURE ANALYSES CONTROL BUILDING HVAC SYSTEMS

Component	Malfunction	Consequences
I. Control Room Air-Conditioning System		
Particulate filters	Excessive dust loading, reduced airflow	System is sized for full flow with fully loaded filters.
Air-conditioning unit casing	Casing failure, air bypasses coil (evaporator)	Partial loss of cooling; redundant unit is available for cooling.
Fan	Fails to start	Loss of one unit; redundant fan is available.
Compressor (refrigerant)	Fails to operate	Loss of one system; redundant system is available for cooling.
Condenser	Tube rupture	Loss of condenser; redundant system is available.
Piping (refrigerant)	Rupture, loss of refrigerant	Loss of one system; redundant system is available.
System Isolation Dampers	Damper fails to open; flow path not available.	Loss of one system; redundant system is available.
II. Control Room Filtration System		
Particulate filters	Excess dust loading; airflow is reduced	Reduced cleanup capabilities; redundant system is available for cleanup.
Fan	Fails to start	One unit is out of service; redundant unit is available for cleanup.
System isolation damper	Damper fails to open; flow path not available.	Loss of one system; redundant system is available.

TABLE 9.4-5 (Sheet 2)

Component	Malfunction	Consequences
III. Control Room Pressurization System		
Particulate filters	Excessive dust loading, reduced airflow	System is sized for full flow with fully loaded filters
Fan	Fails to start	One unit is out of service; redundant unit is available for operation.
System isolation dampers	Damper fails to open; flow path not available.	Loss of one system; redundant system is available.
IV. Class 1E Electrical Equipment Air-Conditioning System		
Particulate filters	Excessive dust loading, reduced airflow	System is sized for full flow with fully loaded filters.
Air-conditioning unit casing	Casing failure, air bypasses coil (evaporator)	Partial loss of cooling; redundant unit is available for cooling.
Fan	Fails to start	Loss of one unit; redundant fan is available.
Compressor (refrigerant)	Fails to operate	Loss of one system; redundant system is available.
Piping (refrigerant)	Rupture, loss of refrigerant	Loss of one system; redundant system is available.
V. Control building supply system, control building exhaust system, and access control exhaust system penetrations of the common auxiliary/control building boundary		
Building isolation dampers	Damper fails to close	Loss of isolation on one side of penetration; redundant damper closes.

TABLE 9.4-6 DESIGN DATA FOR FUEL BUILDING HVAC SYSTEM COMPONENTS*

I. Fuel Building Supply Air System	
A. Supply Air Heating Coil	
Quantity	1
Total heating capacity, Btu/hr	2,196,800
Hot water flow, gpm	110
Design standards	MS
Seismic design	Non-Category I
B. Supply Air Unit	
Quantity	2
Air flow, cfm each	18,000
Static pressure, in. w.g. each	6.4
Motor, hp each	25
Total cooling capacity, Btu/hr each	477,900
Chilled water flow rate, gpm	64
Design codes and standards	
Unit	MS
Coil	MS
Motor	NEMA
Seismic design	Non-Category I
C. Fuel Handling Area Chilled Water Coil	
Quantity	1
Total cooling capacity Btu/hr	175,500
Chilled water flow, gpm	28
Design standards	MS
Seismic design	Non-Category I
II. Spent Fuel Pool Pump Room Coolers	
Quantity	2
Air flow, cfm each	3,500
Static pressure, in. w.g. each	0.92
Motor horsepower, bhp each	2
Total cooling capacity Btu/hr each	77,000
Water flow rate, gpm each	29
Fouling factor	0.002
Tube material	AL6XN SS
Design codes and standards	
Unit	MS
Coil	ASME Section III, Class 3
Motor	IEEE-323

TABLE 9.4-6 (Sheet 2)

Seismic design	Category I
III. Unit Heaters	
A. Lower Level Unit Heater (East Wall)	
Quantity	1
Heating capacity, Btu/hr	168,900
Hot water flow rate, gpm	9
Design standards	
Motor	NEMA
Coil	MS
Seismic design	Non-Category I
B. Lower Level Unit Heater (West Wall)	
Quantity	1
Heating capacity, Btu/hr	168,900
Hot water flow rate, gpm	9
Design standards	
Motor	NEMA
Coil	MS
Seismic design	Non-Category I
C. Lower Level Unit Heater (South Wall)	
Quantity	1
Heating capacity, Btu/hr each	126,700
Hot water flow rate, gpm each	7
Design standards	
Motor	NEMA
Coil	MS
Seismic design	Non-Category I
D. Upper Level Unit Heater (Hot-Water Type)	
Quantity	2
Heating capacity, Btu/hr each	190,000
Hot water flow rate, gpm each	10
Design standards	
Motor	NEMA
Coil	MS
Seismic design	Non-Category I
E. Upper Level Unit Heater (Electrical-Resistance Type)	
Quantity	4
Rating, kW each	30
Design standard	MS
Seismic design	Non-Category I

TABLE 9.4-6 (Sheet 3)

IV. Emergency Exhaust System	
A. Adsorber Train	
Quantity	2
Particulate filters, each	6
HEPA filters, each	12
Charcoal, lbs each	1,937 (approx.)
Design criterion (unit)	Reg. Guide 1.52
Seismic design	Category I
B. Electric Heaters	
Quantity	2
Rating, kW each	37
Design standard	IEEE-323
Seismic design	Category I
C. Fans	
Quantity	2
Type	Centrifugal
Air flow, cfm each	9,000
Static pressure, in. w.g. each	11.75
Motor brake horsepower, bhp each	25
Design codes and standards	
Fan	MS
Motor	IEEE-323

* NOTE: Design parameters shown in Table 9.4-6 represent the values specified in procurement specifications. Minor variations in performance characteristics may exist between individual components. Adequate margin is maintained to ensure components can perform their design function.

TABLE 9.4-7 SINGLE-FAILURE ANALYSIS - EMERGENCY EXHAUST SYSTEM, SPENT FUEL POOL PUMP ROOM COOLERS, AND FUEL BUILDING HVAC ISOLATION

Component	Malfunction	Consequences
Exhaust system filter/ adsorber unit particulate filters	Excess dust loading; airflow is reduced	System is sized for full-flow with fully loaded filters.
Exhaust fan	Fails to start	One unit is out of service; redundant unit is capable of providing cleanup.
Exhaust system discharge damper	Fails closed; flow path is not available	One unit is out of service; redundant unit is capable of providing cleanup.
Auxiliary/fuel building normal exhaust system isolation dampers	Damper fails to close; flow path is not isolated	One damper is out of service; redundant damper is capable of providing required closure.
Fuel building supply system ductwork isolation dampers	Damper fails to close; flow path is not isolated	One damper is out of service; redundant damper is capable of providing required closure.
Pump room cooler fan	Fails to start	One unit is out of service; redundant unit is capable of providing cooling requirements.

TABLE 9.4-8 DESIGN DATA FOR AUXILIARY BUILDING HVAC SYSTEM COMPONENTS*

I.	Auxiliary Building Supply Air Unit	
	Quantity	1
	Air flow, cfm	10,800
	Static pressure, in. w.g.	4.84
	Motor horsepower, hp	15
	Total cooling capacity, Btu/hr	802,000
	Total heating capacity, Btu/hr	1,167,000
	Chilled water flow, gpm	95
	Hot water flow, gpm	60
	Design codes and standards	
	Unit	MS
	Motor	NEMA
	Codes	MS
	Seismic design	Non-Category I
II.	Main Steam Tunnel Supply Air Unit	
	Quantity	1
	Air flow, cfm	23,000
	Static pressure, in. w.g.	6.1
	Motor horsepower, hp	40
	Heating capacity, Btu/hr	2,186,000
	Hot water flow rate, gpm	109
	Cooling capacity, Btu/hr	1,278,000
	Chilled water flow rate, gpm	106
	Design codes and standards	
	Unit	MS
	Motor	NEMA
	Codes	MS
	Seismic design	Non-Category I
III.	Auxiliary/Fuel Building Normal Exhaust System	
	A. Adsorber Train	
	Quantity	1
	Particulate filters, each	25
	HEPA filters, each	50
	Charcoal, lbs each	6,300
	Design criterion	Reg. Guide 1.140
	Seismic design	Non-Category I

TABLE 9.4-8 (Sheet 2)

B. Fans	
Quantity	2
Type	Centrifugal
Air flow, cfm each	32,000
Static pressure, in. w. g.	10.95
Motor horsepower, hp each	100
Design codes and standards	
Fan	MS
Motor	NEMA
Seismic design	Non-Category I
C. Sample Panel Exhaust Booster Fan	
Quantity	1
Type	Axial
Air flow, cfm	1,180
Static pressure, in. w.g.	0.25
Motor horsepower, hp	0.33
Design codes and standards	
Fan	MS
Motor	NEMA
Seismic design	Non-Category I
D. Laundry Dryer Exhaust System	
Quantity	1
Flow, cfm max	9,000
Motor horsepower, hp	30
Housing material	Stainless steel
Design codes and standards	
Fan	Commercial
Motor	NEMA
Seismic design	Non-Category I
IV. Main Steam Tunnel Exhaust System	
Quantity	2
Air flow, cfm each	16,500
Static pressure, in. w.g.	6.1
Motor horsepower, hp each	25
Design codes and standards	
Fan	MS
Motor	NEMA
Seismic design	Non-Category I

TABLE 9.4-8 (Sheet 3)

V. Nonessential Recirculation Units	
A. Electrical Equipment Room Fan Coil Units	
Quantity	1
Equipment No.	SGL02
Air flow, cfm	3,930
Static pressure in. w.g.	3.80
Motor horsepower, hp	5
Total cooling capacity, Btu/hr	205,000
Chilled water flow rate, gpm	20
Design codes and standards	
Unit	MS
Motor	NEMA
Coil	MS
Seismic design	Non-Category I
Quantity	1
Equipment No.	SGL20
Air flow, cfm	10,000
Static pressure in. w.g.	2.38
Motor horsepower, hp	7.5
Total cooling capacity, Btu/hr	272,250
Chilled water flow rate, gpm	25
Design codes and standards	
Unit	MS
Motor	NEMA
Coil	MS
Seismic design	Non-Category I
B. Component Cooling Water Pump Room Fan Coil Unit	
Quantity	2
Air flow, cfm	4,000
Static pressure, in. w.g.	3.22
Motor horsepower, hp	5
Total cooling capacity, Btu/hr	300,000
Chilled water flow rate, gpm	35
Design codes and standards	
Unit	MS
Motor	NEMA
Coil	MS
Seismic design	Non-Category I

TABLE 9.4-8 (Sheet 4)

C. Ground Floor Corridor Fan Coil Unit	
Quantity	1
Flow, cfm	2,600
Static pressure, in. w.g.	3.27
Motor horsepower, hp	3
Total cooling capacity, Btu/hr	137,400
Chilled water flow rate, gpm	16
Design codes and standards	
Unit	MS
Motor	NEMA
Coil	MS
Seismic design	
D. Laundry Decon Facility Fan Coil Unit	
Quantity	1
Flow, cfm	12,000
Static pressure, in. w.g.	2.23
Motor horsepower, hp	10
Total cooling capacity, Btu/hr	455,000
Chilled water flow rate, gpm	50
Design codes and standards	
Unit	Commercial
Motor	NEMA
Coil	Commercial
Seismic design	Non-Category I
E. Normal Charging Pump Room Fan Coil Unit	
Quantity	1
Air flow, cfm	2,514
Static pressure, in. w.g.	0.40
Motor horsepower, hp	1.5
Total cooling capacity, Btu/hr	129,000
Chilled water flow rate, gpm	15.2
Design codes and standards	
Unit	Commercial
Motor	NEMA
Coil	Commercial
Seismic design	Non-Category I
F. Basement Corridor Fan Coil Unit	
Quantity	1
Flow, cfm	900

TABLE 9.4-8 (Sheet 5)

Static pressure, in. w.g.	2.30
Motor horsepower, hp	1.5
Total cooling capacity, Btu/hr	49,000
Chilled water flow rate, gpm	6
Design codes and standards	
Unit	MS
Motor	NEMA
Coil	MS
Seismic design	Non-Category I
G. Radioactive Material Storage Building (RSB) Fan Coil Unit	
Quantity	2
Flow, cfm	4,000
Static pressure, in. w.g.	1.23
Motor horsepower, hp	2
Total cooling capacity, Btu/hr	121,800
Chilled water flow rate, gpm	14.0
Design codes and standards	
Unit	Commercial
Motor	NEMA
Coil	Commercial
Seismic design	Non-Category I
VI. Safety-Related Recirculation Units	
A. Safety-Injection Pump Room Cooler	
Quantity	2
Flow, cfm each	10,100
Static pressure, in. w.g.	1.30
Motor horsepower, hp each	10
Total cooling capacity, Btu/hr each	220,000
Water flow rate, gpm each	88
Fouling factor	0.002
Tube material	AL6XN SS
Design codes and standards	
Unit	MS
Motor	IEEE-323
Coil	ASME Section III, Class 3
Seismic design	Category I
B. RHR Pump Room Cooler	
Quantity	2
Flow, cfm each	10,100

TABLE 9.4-8 (Sheet 6)

	Static pressure, in. w.g.	1.30
	Motor horsepower, hp each	10
	Total cooling capacity, Btu/hr each	220,000
	Water flow rate, gpm each	88
	Fouling factor	0.002
	Tube material	AL6XN SS
	Design codes and standards	
	Unit	MS
	Motor	IEEE-323
	Coil	ASME Section III, Class 3
	Seismic Design	Category I
C.	Component Cooling Water Pump Room Cooler	
	Quantity	2
	Flow, cfm each	14,700
	Static pressure, in. w.g.	1.70
	Motor horsepower, hp each	15
	Total cooling capacity, Btu/hr each	320,000
	Water flow rate, gpm each	128
	Fouling factor	0.002
	Tube material	AL6XN SS
	Design codes and standards	
	Unit	MS
	Motor	IEEE-323
	Coil	ASME Section III, Class 3
	Seismic design	Category I
D.	Containment Spray Pump Room Cooler	
	Quantity	2
	Flow, cfm each	10,000
	Static pressure, in. w.g.	1.30
	Motor horsepower, hp each	10
	Total cooling capacity, Btu/hr each	220,000
	Water flow rate, gpm each	88
	Fouling factor	0.002
	Tube material	AL6XN SS
	Design codes and standards	
	Unit	MS
	Motor	IEEE-323
	Coil	ASME Section III, Class 3
	Seismic design	Category I

TABLE 9.4-8 (Sheet 7)

E. Auxiliary Feedwater Pump Room Cooler	
Quantity	2
Flow, cfm each	14,680
Static pressure, in. w.g.	1.30
Motor brake horsepower, hp each	10
Total cooling capacity, Btu/hr each	320,000
Water flow rate, gpm each	128
Fouling factor	0.002
Tube Material	AL6XN SS
Design codes and standards	
Unit	MS
Motor	IEEE-323
Coil	ASME Section III, Class 3
Seismic design	Category I
F. Penetration Room Cooler	
Quantity	2
Flow, cfm each	18,300
Static pressure, in. w.g.	2.16
Motor horsepower, hp each	20
Total cooling capacity, Btu/hr each	122,450
Water flow rate, gpm each	100
Fouling factor	0.002
Tube material	AL6XN SS
Design codes and standards	
Unit	MS
Motor	IEEE-323
Coil	ASME Section III, Class 3
Seismic design	Category I
G. Charging Pump Room Cooler	
Quantity	2
Flow, cfm each	14,700
Static pressure, in. w.g.	1.30
Motor horsepower, hp each	10.0
Total cooling capacity, Btu/hr each	320,000
Water flow rate, gpm each	128
Fouling factor	0.002
Tube material	AL6XN SS

TABLE 9.4-8 (Sheet 8)

Design codes and standards	
Unit	MS
Motor	IEEE-323
Coil	ASME Section III, Class 3
Seismic design	Category I
VII. Unit Heaters	
A. Auxiliary Building Basement Corridor Unit Heater	
Quantity	2
Heating capacity, Btu/hr each	60,000
Hot water flow, gpm each	3
Design standards	
Motor	NEMA
Coil	MS
Seismic design	Non-Category I
B. Auxiliary Building Laundry Decontamination Facility Unit Heater	
Quantity	1
Heating capacity, Btu/hr	80,000
Hot water flow, gpm	4
Design standards	
Motor	NEMA
Coil	MS
Seismic design	Non-Category I
C. Auxiliary Building Decontamination Room Unit Heater	
Quantity	1
Heating capacity, Btu/hr	100,000
Hot water flow, gpm	5
Design standards	
Motor	NEMA
Coil	MS
Seismic design	Non-Category I
D. Auxiliary Building Hot Machine Shop Unit Heater	
Quantity	2
Heating capacity, Btu/hr each	80,000
Hot water flow, gpm each	4
Design standards	
Motor	NEMA
Coil	MS
Seismic design	Non-Category I

TABLE 9.4-8 (Sheet 9)

E. Auxiliary Building Corridor Unit Heater	
Quantity	2
Heating capacity, Btu/hr each	80,000
Hot water flow, gpm each	4
Design standards	
Motor	NEMA
Coil	MS
Seismic design	Non-Category I
F. Auxiliary Building HVAC Equipment Room Unit Heater	
Quantity	3
Heating capacity, Btu/hr each	100,000
Hot water flow, gpm each	5
Design standards	
Motor	NEMA
Coil	MS
Seismic design	Non-Category I
G. Auxiliary Building Containment Personnel Access Area Unit Heater	
Quantity	2
Heating capacity, Btu/hr each	60,000
Hot water flow, gpm each	3
Design standards	
Motor	NEMA
Coil	MS
Seismic design	Non-Category I
H. Auxiliary Building Boric Acid Storage Tank Area Unit Heater	
Quantity	2
Type	Electric
Heating rating, kW each	15
Design standards	MS
Seismic design	Non-Category I
I. Pipe Chase Unit Heater	
Quantity	2
Type	Electric
Heater rating, kW each	5
Design standards	MS
Seismic design	Non-Category I
J. Pipe Chase Unit Heater	
Quantity	4
Type	Electric

TABLE 9.4-8 (Sheet 10)

	Heater rating, kW each	10
	Design standards	MS
	Seismic design	Non-Category I
K.	Ram Storage Building Unit Heater	
	Quantity	2
	Type	Electric
	Heater rating, kW each	20 kW
	Design standards	MS
	Seismic design	Non-Category I
VIII.	Transfer Fan	
	Quantity	1
	Air flow, cfm	250
	Static pressure, in. w.g.	0.82
	Motor horsepower, hp	0.25
	Design codes and standards	
	Fan	MS
	Motor	NEMA
	Seismic design	Non-Category I

* NOTE: Design parameters shown in Table 9.4-8 represent the values specified in procurement specifications. Minor variations in performance characteristics may exist between individual components. Adequate margin is maintained to ensure components can perform their design function.

TABLE 9.4-9 SINGLE-FAILURE ANALYSES - PUMP ROOM COOLERS, PENETRATION ROOM COOLERS AND EMERGENCY EXHAUST SYSTEM*

Component	Malfunction	Consequences
Fan	Fails to start	One unit is out of service; redundant unit is capable of providing cooling requirements.
Discharge damper**	Fails closed, airflow is lost	One unit is out of service; redundant unit is capable of providing cooling requirements.
Emergency exhaust system isolation damper	Damper fails to open; exhaust airflow is lost	One system is out of service; redundant system is capable of providing required exhaust flow.
Isolation dampers for those non-safety-related HVAC systems which penetrate the auxiliary building boundary	Damper fails to close	Loss of isolation of one side of penetration; redundant damper closes.

* Applies only to that portion of the system located within the auxiliary building.

** Applies only to penetration room coolers and one component cooling water pump room cooler.

TABLE 9.4-10 DESIGN DATA FOR TURBINE BUILDING VENTILATION SYSTEM COMPONENTS*

I. Main Building Supply System	
A. Operating Floor	
1. Supply Units	
Quantity	2
Air flow, cfm each	45,000
Static pressure, in. w.g.	1.4
Motor horsepower, hp each	40
Design standards	
Fan	MS
Motor	NEMA
2. Supply Units	
Quantity	2
Air flow, cfm each	45,000
Static pressure, in. w.g.	1.53
Motor horsepower, hp each	40
Design standards	
Fan	MS
Motor	NEMA
3. Supply Unit	
Quantity	1
Air flow, cfm	24,000
Static pressure, in. w.g.	1.96
Motor horsepower, hp each	20
Design standards	
Fan	MS
Motor	NEMA
B. Mezzanine Floor	
1. Supply Units	
Quantity	5
Air flow, cfm each	45,000
Static pressure, in. w.g.	1.4
Motor horsepower, hp each	40
Design standards	
Fan	MS
Motor	NEMA
2. Supply Units	
Quantity	2
Air flow, cfm each	45,000

TABLE 9.4-10 (Sheet 2)

Static pressure, in. w.g.	1.53
Motor horsepower, hp each	40
Design standards	
Fan	MS
Motor	NEMA
3. Supply Unit	
Quantity	1
Air flow, cfm	24,000
Static pressure, in. w.g.	1.96
Motor horsepower, hp each	20
Design standards	
Fan	MS
Motor	NEMA
C. Ground Floor	
1. Supply Units	
Quantity	3
Air flow, cfm each	45,000
Static pressure, in. w.g.	1.4
Motor horsepower, hp each	40
Design standards	
Fan	MS
Motor	NEMA
2. Supply Units	
Quantity	2
Air flow, cfm each	45,000
Static pressure, in. w.g.	1.53
Motor horsepower, hp each	40
Design standards	
Fan	MS
Motor	NEMA
3. Supply Units	
Quantity	1
Air flow, cfm	24,000
Static pressure, in. w.g.	1.4
Motor horsepower, hp	20
Design standards	
Fan	MS
Motor	NEMA

TABLE 9.4-10 (Sheet 3)

D. Communication Corridor	
Quantity	1
Air flow, cfm	24,000
Static pressure, in. e.g.	1.86
Motor horsepower, hp	15
Design standards	
Fan	MS
Motor	NEMA
II. Main Building Exhaust System	
A. Exhaust Fans (large)	
Quantity	8
Air flow, cfm each	90,000
Static pressure, in. w.g.	1.74
Motor horsepower, hp each	50
B. Exhaust Fans (small)	
Quantity	2
Air flow, cfm each	40,000
Static pressure, in. w.g.	1.08
Motor horsepower, hp each	10
Design standards	
Fan	MS
Motor	NEMA
C. Toilet Exhaust Fans	
Quantity	2
Air flow, cfm each	500
Static pressure, in. w.g.	0.73
Motor horsepower, hp each	0.25
Design standards	
Fan	MS
Motor	NEMA
D. Elevator Machine Room Exhaust Fan	
Quantity	1
Air flow, cfm	500
Static pressure, in. w.g.	0.27
Motor horsepower, hp	1/3
Design standards	
Fan	MS
Motor	NEMA

TABLE 9.4-10 (Sheet 4)

III. Turbine Building Unit Heaters	
A. Operating Floor	
Quantity	4
Heating capacity, Btu/hr each	330,000
Hot water flow rate, gpm each	17
Design standards	
Coil	MS
Motor	NEMA
B. Mezzanine Floor	
Quantity	2
Heating capacity, Btu/hr each	220,000
Hot water flow rate, gpm each	11
Design standards	
Coil	MS
Motor	NEMA
C. Ground Floor	
Quantity	4
Heating capacity, Btu/hr each	220,000
Hot water flow rate, gpm each	11
Design standards	
Coil	MS
Motor	NEMA
D. Stairwells	
Quantity	8
Type	Electric
Heating capacity, kW each	7.5
Design standards	
Coil	MS
Motor	Manufacturer's Standard
E. Communication Corridor	
a. Elevation 2073'-6"	
Quantity	2
Heating capacity, Btu/hr each	120,000
Hot water flow rate, gpm each	1
Design standards	
Coil	MS
Motor	NEMA
b. Elevation 2,032	
Quantity	2

TABLE 9.4-10 (Sheet 5)

Heating capacity, Btu/hr each	20,000
Hot water flow rate, gpm each	1
Design standards	
Coil	MS
Motor	NEMA
c. Elevation 2,000	
Quantity	1
Heating capacity, Btu/hr each	60,000
Hot water flow rate, gpm	3
Design standards	
Coil	MS
Motor	NEMA
IV. Lube Oil Room Ventilation and Heating System	
A. Supply System	
Quantity	1
Air flow, cfm	2,000
Static pressure, in. w.g.	1.69
Motor horsepower, hp	1.5
Heating capacity, Btu/hr	220,000
Hot water flow, gpm	11
Design standards	
Fan	MS
Motor	NEMA
B. Exhaust System	
Quantity	1
Air flow, cfm	2,000
Static pressure, in. w.g.	1.01
Motor horsepower, hp	1
Design standards	
Fan	MS
Motor	NEMA
V. Computer Room HVAC System	
Quantity	2
Air flow, cfm each	13,200
Static pressure, in. w.g.	4.08
Motor horsepower, hp each	20
Total cooling capacity, Btu/hr each (total)	350,500
Chilled water flow rate, gpm each	42
Heating capacity, Btu/hr each	285,000

TABLE 9.4-10 (Sheet 6)

	Hot water flow rate, gpm each	15
	Design standards	
	Fan	MS
	Motor	NEMA
	Coil	MS
VI.	Conference Room HVAC System	
	A. Recirculation Unit	
	Quantity	1
	Air flow, cfm	1,250
	Static pressure, in. w.g.	1.90
	Motor horsepower, hp each	1.5
	Total cooling capacity, Btu/hr (total)	41,000
	Chilled water flow rate, gpm	8
	Design standards	
	Fan	MS
	Motor	NEMA
	Coil	MS
VII.	Condenser Air Removal Filtration System	
	Quantity	2
	Air flow, cfm each	1,000
	Static pressure, in. w.g.	10.0
	Motor horsepower, hp each	3.0
	Prefilters, No.	1
	HEPA filters, No.	2
	Charcoal, lbs	150
	Design criterion	Reg. Guide 1.140
	Seismic design	Non-Category I
VIII.	Battery Room Chiller Water Coil	
	Quantity	2
	Type	Chilled water
	Air flow, cfm each	720
	Total cooling capacity Btu/hr each	58,000
	Water flow, gpm each	7
	Design standard	MS
IX.	EHC Cabinet Room Air-Conditioning System	
	Quantity, loops	2
	Type	Ductless VRV-III-S Heat Pump
	Air flow, cfm, total	2540//1880

TABLE 9.4-10 (Sheet 7)

Backup Room Air Conditioners	
Quantity, loops	2
Type	Room air conditioner
Air flow, cfm, total	500
Total cooling capacity, Btu/hr	124,800
Power input, kW	14.4
Design Standards (Backup Room Air-Conditioners)	MS

* NOTE: Design parameters shown in Table 9.4-10 represent the values specified in procurement specifications. Minor variations in performance characteristics may exist between individual components. Adequate margin is maintained to ensure components can perform their design function.

TABLE 9.4-11 DESIGN DATA FOR RADWASTE BUILDING HVAC SYSTEM COMPONENTS*

I. The supply air system consists of a particulate filter, hot water heating coil, chilled water cooling coil, centrifugal fan, and electric motor driver.

Quantity	1
Air flow, cfm	10,800
Static pressure, in. w.g.	2.47
Motor horsepower	7.5
Cooling capacity, Btu/hr (total)	345,100
Heating capacity, Btu/hr	1,108,00
Chilled water flow rate, gpm	41
Hot water flow rate, gpm	55
Design standards	
Fan	MS
Motor	NEMA
Coil	MS

II. Unit heaters are used or provide supplemental heating.

A. Basement Floor

Quantity	1
Heating capacity, Btu/hr	140,000
Hot water flow rate, gpm	7
Type	Hot water
Design standards	
Coil	MS
Motor	NEMA

B. Ground Floor

Quantity	2
Heating capacity, Btu/hr each	78,600
Hot water flow rate, gpm each	4
Type	Hot water
Design standards	
Coil	MS
Motor	NEMA

C. El. 2,021

Quantity	2
Heating capacity, Btu/hr each	140,000
Hot water flow rate, gpm each	7
Type	Hot water

TABLE 9.4-11 (Sheet 2)

Design standards	
Coil	MS
Motor	NEMA
D. Second Floor	
Quantity	4
Heating capacity, Btu/hr each	195,000
Hot water flow rate, gpm each	10
Type	Hot water
Quantity	1
Heating capacity, Btu/hr	100,000
Hot water flow rate, gpm	5
Type	Hot water
Design standards	
Coil	MS
Motor	NEMA
E. Drumming Area Unit Heaters	
Quantity	3
Type	Electric
Heater rating, kW each	40
Design standards	MS

III. Local fan-coil units are used to provide supplemental cooling on the basement and ground floors. Each unit consists of a chilled water cooling coil, centrifugal fan, and electric motor driver.

Quantity	2
Air flow, cfm each	1,700
Static pressure, in. w.g.	3.0
Motor horsepower, each	2
Total cooling cap. Btu/hr each	90,000
Chilled water flow rate, gpm each	11
Design standards	
Fan	MS
Motor	NEMA
Coil	MS

IV. Fan-coil units are provided to supplement the cooling of the evaporator rooms. Each unit consists of a chilled water cooling coil, centrifugal fan, and electric motor driver.

A. Recycle Evaporator Room	
Quantity	1
Air flow, cfm	3,200

TABLE 9.4-11 (Sheet 3)

Static pressure, in. w.g.	2.2
Motor horsepower	3
Total cooling cap., Btu/hr	169,000
Chilled water flow rate, gpm	20
Design standards	
Fan	MS
Motor	NEMA
Coil	MS
B. Waste Evaporator Room	
Quantity	1
Air flow, cfm	3,200
Static pressure, in. w.g.	2.2
Motor horsepower	3
Total cooling cap., Btu/hr	169,000
Chilled water flow rate, gpm	20
Design standards	
Fan	MS
Motor	NEMA
Coil	MS
C. SLWS Evaporator Room	
Quantity	1
Air flow, cfm	3,200
Static pressure, in. w.g.	2.2
Motor horsepower	3
Total cooling cap., Btu/hr	169,000
Chilled water flow rate, gpm	20
Design standards	
Fan	MS
Motor	NEMA
Coil	MS

V. Fan-coil units are used to provide the cooling of the control rooms and the sample laboratory. Each unit consists of a chilled water cooling coil, centrifugal fan, and electric motor driver. In addition, the main control room fan-coil unit is provided with a heating coil.

A. Control Room (Solidification)	
Quantity	1
Air flow, cfm	500
Static pressure, in. w.g.	1.3
Motor horsepower	0.75

TABLE 9.4-11 (Sheet 4)

Total cooling, cap., Btu/hr	15,100
Chilled water flow rate, gpm	2.0
Design standards	
Fan	MS
Motor	NEMA
Coil	MS
B. Sample Laboratory	
Quantity	1
Air flow, cfm	500
Static pressure, in. w.g.	1.3
Motor horsepower	0.75
Total cooling cap., Btu/hr	15,100
Chilled water flow, gpm	2.0
Design standards	
Fan	MS
Motor	NEMA
Coil	MS
C. Control Room	
Quantity	1
Air flow, cfm	1,700
Static pressure, in. w.g.	2.5
Motor horsepower	1.5
Total cooling cap., Btu/hr (total)	42,100
Heating capacity, Btu/hr	40,400
Chilled water flow rate, gpm	5
Hot water flow rate, gpm	2.0
Design standards	
Fan	MS
Motor	NEMA
Coil	MS

VI. Transfer Fan

A fan is provided to transfer air from the radwaste building to the personnel access tunnel. The unit consists of a propeller fan and electric motor driver.

Quantity	1
Air flow, cfm	250
Static pressure, in. w.g.	0.81
Motor horsepower	0.25

TABLE 9.4-11 (Sheet 5)

Design standards	
Fan	MS
Motor	NEMA

VII. The radwaste building exhaust system consists of particulate filters and charcoal adsorption trains, centrifugal fans, and electric motor drivers.

A. Adsorber Train	
Quantity	1
Particulate filters	9
HEPA filters	18
Charcoal, lbs	1800
Bed depth, in.	2
Type	Gasketless
Design criterion	Reg. Guide 1.140
Seismic design	Non-Category I
B. Fans	
Quantity	2
Type	Centrifugal
Air flow, cfm each	12,000
Static pressure, in. w.g.	9.16
Motor horsepower, hp each	25
Design standards	
Fan	MS
Motor	NEMA
C. Fume Hood Booster Fan	
Quantity	1
Type	Axial
Air flow, cfm	2,200
Static pressure, in. w.g.	1.0
Motor horsepower, hp	1
Design standards	
Fan	MS
Motor	NEMA

* NOTE: Design parameters shown in Table 9.4-11 represent the values specified in procurement specifications. Minor variations in performance characteristics may exist between individual components. Adequate margin is maintained to ensure components can perform their design function.

TABLE 9.4-12 DESIGN DATA FOR THE CONTAINMENT HVAC SYSTEM COMPONENTS*

I. Containment Shutdown Purge Supply System	
A. Supply Air Unit	
Quantity	1
Air flow, cfm	20,000
Static pressure, in. w.g.	4.94
Motor horsepower, hp	25
Total cooling capacity, Btu/hr	2,680,000
Hot water flow, gpm	106
Design codes and standards	
Unit	MS
Motor	NEMA
Coils	MS
Seismic Design	Non-Category I
B. Containment Isolation Valves	
Quantity	4
Type	Butterfly (wafer)
Material	Carbon steel
Actuation	Air cylinder
Failure mode	Closed
Size, in.	36
Design codes	ASME Section III, Class 2
Seismic design	Category I
C. Containment Penetration	
Size, in.	36
Material	Carbon steel
Design codes	ASME Section III, Class E
Seismic design	Category I
II. Containment Minipurge Supply System	
A. Supply Air Unit	
Quantity	1
Air flow, cfm	4,000
Static pressure, in. w.g.	4.25
Motor horsepower, hp	5
Total heating capacity, Btu/hr	324,000
Hot water flow, gpm	17

TABLE 9.4-12 (Sheet 2)

Design codes and standards	
Unit	MS
Motor	NEMA
Coils	MS
Seismic design	Non-Category I
B. Containment Isolation Valves	
Quantity Isolation Valves	
Quantity	4
Type	Butterfly (wafer)
Material	Carbon steel
Actuation	Air cylinder
Failure mode	Closed
Size, in.	18
Design codes	ASME Section III, Class 2
Seismic design	Category I
III. Containment Purge Exhaust System	
A. Exhaust Fans	
1. Containment Shutdown Purge Exhaust Fan	
Quantity	1
Air flow, cfm	20,000
Static pressure, in w.g.	13.3
Motor horsepower, hp	60
Design codes and standards	
Fan	MS
Motor	NEMA
2. Containment Minipurge Exhaust Fan	
Quantity	1
Air flow, cfm	4,000
Static pressure, in. w.g.	5.0
Motor horsepower, hp	5
Design codes and standards	
Fan	MS
Motor	NEMA
B. Filter Adsorber Unit	
Quantity	1
Particulate filters	20
HEPA filters	40
Charcoal, lbs	3,500
Bed depth, in.	2

TABLE 9.4-12 (Sheet 3)

Type	Gasketless
Design criterion	Reg. Guide 1.140
Seismic design	Non-Category I
C. Containment Isolation Valves	
1. Containment Shutdown Purge	
Quantity	2
Type	Butterfly (wafer)
Material	Carbon steel
Actuation	Air cylinder
Failure mode	Closed
Size in.	36
Design codes	ASME Section III, Class 2
Seismic design	Category I
2. Containment Minipurge	
Quantity	2
Type	Butterfly (wafer)
Material	Carbon steel
Actuation	Air cylinder
Failure mode	Closed
Size, in.	18
Design codes	ASME Section III, Class 2
Seismic design	Category I
D. Containment Penetration	
Size, in.	36
Material	Carbon steel
Design codes	ASME Section III, Class 2
Seismic design	Category I
IV. CRDM Cooling Fans	
Quantity	4
Type	Centrifugal
Air flow, cfm each	20,000
Static pressure, in. w.g.	4.5
Motor horsepower, hp each	35
Design codes and standards	
Fan	MS
Motor	NEMA
V. Cavity Cooling Fans	
Quantity	2
Type	Vaneaxial

TABLE 9.4-12 (Sheet 4)

	Air flow, cfm each	16,000
	Static pressure, in. w.g.	4.6
	Motor horsepower, hp each	25
	Design codes and standards	
	Fan	MS
	Motor	NEMA
VI.	Machine Room Exhaust Fan	
	Quantity	1
	Type	Centrifugal
	Air flow, cfm each	1,150
	Static pressure, in. w.g.	0.1
	Motor horsepower, hp each	0.5
	Design codes and standards	
	Fan	MS
	Motor	NEMA
IVII.	Pressurizer Cooling Fan	
	Quantity	1
	Type	Vaneaxial
	Air flow, cfm each	2,400
	Static pressure, in. w.g.	0.92
	Motor horsepower, hp each	0.75
	Design codes and standards	
	Fan	MS
	Motor	NEMA
VIII.	Ductwork	
	Material - inside secondary shield wall	Stainless steel
	Material - outside secondary shield wall	Galvanized steel

* NOTE: Design parameters shown in Table 9.4-12 represent the values specified in procurement specifications. Minor variations in performance characteristics may exist between individual components. Adequate margin is maintained to ensure components can perform their design function.

TABLE 9.4-13 COMPARISON OF CONTAINMENT MINIPURGE CONTAINMENT ISOLATION VALVES WITH BTP CSB 6-4

Branch Technical Position	Union Electric Position
B.1	
The on-line purge system should be designed in accordance with the following criteria:	
B.1.a	
General Design Criterion 54 requires that the reliability and performance capabilities of containment isolation valves reflect the importance of safety of isolating the systems penetrating the containment boundary. Therefore, the performance and reliability of the purge system isolation valves should be consistent with the operability assurance program outlined in Branch Technical Position MEB-2, "Pump and Valve Operability Assurance Program." (Also see SRP Section 3.10.) The design basis for the valves and actuators should include the build-up of containment pressure for the LOCA break spectrum, and the supply line and exhaust line flows as a function of time up to and during valve closure.	Complies.
B.1.b	
The number of supply and exhaust lines that may be used should be limited to one supply line and one exhaust line, to improve the reliability of the isolation function as required by General Design Criterion 54, and to facilitate compliance with the requirements of Appendix K to 10 CFR Part 50 regarding the containment pressure used in the evaluation of the emergency core cooling system effectiveness and 10 CFR Part 100 regarding offsite radiological consequences.	Complies. System employs two lines, one for the supply system and one for the exhaust system.

TABLE 9.4-13 (Sheet 2)

Branch Technical Position	Union Electric Position
B.1.c	
The size of the lines should not exceed about eight inches in diameter, unless detailed justification for larger line sizes is provided, to improve the reliability and performance capability of the isolation and containment functions as required by General Design Criterion 54, and to facilitate compliance with the requirements of Appendix K to 10 CFR Part 50 regarding the containment pressure used in evaluating the emergency core cooling system effectiveness and 10 CFR Part 100 regarding the offsite radiological consequences.	Does not comply. Minipurge containment isolation valve size is 18-inch-diameter butterfly valve. A minipurge flow rate of 4,000 cfm is required to maintain inplant containment doses, based on the assumptions and source terms of Regulatory Guide 1.112, at 7 MPC during occupation (see Section 11.3). At a flow rate of 4,000 cfm, 8-inch-diameter valves and system result in prohibitive velocities and pressure drops.
B.1.d	
As required by General Design Criterion 54, the containment isolation provisions for the purge system lines should meet the standards appropriate to engineered safety features; i.e., quality, redundancy, testability and other appropriate criteria, to reflect the importance to safety of isolating these lines. General Design Criterion 56 establishes explicit requirements for isolation barriers in purge system lines.	Complies.
B.1.e	
To improve the reliability of the isolation function, which is addressed in General Design Criterion 54, instrumentation and control systems provided to isolate the purge system lines should be independent and actuated by diverse parameters; e.g., containment pressure, safety injection actuation, and containment radiation level. Furthermore, if energy is required to close the valves, at least two diverse sources of energy shall be provided, either of which can effect the isolation function.	Complies, with the following clarification on diverse energy sources. The inboard and outboard minipurge isolation valves are powered from different separation groups.

TABLE 9.4-13 (Sheet 3)

Branch Technical Position	Union Electric Position
B.1.f	
Purge system isolation valve closure times, including instrumentation delays, should not exceed five seconds, to facilitate compliance with 10 CFR Part 100 regarding offsite radiological consequences.	Does not comply. Minipurge valve stroke time is 5 seconds. After a LOCA, a CPIS is generated within 2 seconds. With an assumed signal delay of 4 seconds, the valves will be closed within 11 seconds after a LOCA. Radiological consequence calculations include this 11-second exposure pathway and 10CFR100 criteria are met.
B.1.g	
Provisions should be made to ensure that isolation valve closure will not be prevented by debris which could potentially become entrained in the escaping air and steam.	Complies. See also Reference 11 of Section 18.2.18.
B.2	
The purge system should not be relied on for temperature and humidity control within the containment.	Complies.
B.3	
Provisions should be made to minimize the need for purging of the containment by providing containment atmosphere cleanup systems within the containment.	Complies. See Figure 9.4-6 sheet 3.

TABLE 9.4-13 (Sheet 4)

Branch Technical Position	Union Electric Position
B.4	
Provisions should be made for testing the availability of the isolation function and the leakage rate of the isolation valves during reactor operation.	Limited compliance. The actuation logic tests of the SSPS and BOP-ESFAS are performed during operation. The channel operational tests of the containment purge gaseous exhaust radiation channels are performed during operation. The minipurge valve leakage rate testing is performed during operation. However, the slave relay testing (K630), containment purge gaseous exhaust radiation channel calibrations, and response time testing are performed during refueling outages.
B.5	
The following analyses should be performed to justify the containment purge system design:	
B.5.a	
An analysis of the radiological consequences of a loss-of-coolant accident. The analysis should be done for a spectrum of break sizes, and the instrumentation and setpoints that will actuate the purge valves closed should be identified. The source term used in the radiological calculations should be based on a calculation under the terms of Appendix K to determine the extent of fuel failure and the concomitant release of fission products, and the fission product activity in the primary coolant. A pre-existing iodine spike should be considered in determining primary coolant activity. The volume of containment in which fission products are mixed should be justified, and the fission products from the above sources should be assumed to be released through the open purge valves during the maximum interval required for valve closure. The radiological consequences should be within 10 CFR Part 100 guideline values.	Limited compliance. Radiological consequences are determined for the limiting break, not a spectrum of breaks (see Section 15.6.5.4.1.4). Instrumentation setpoints are identified in the Technical Specification 3.3.2 Bases for CIS-A. Source term data and other assumptions are as discussed in Section 15.6.5.4.1.4 and Tables 15.6-6 and 15A-1.

TABLE 9.4-13 (Sheet 5)

Branch Technical Position	Union Electric Position
B.5.b	
An analysis which demonstrates the acceptability of the provisions made to protect structures and safety-related equipment; e.g., fans, filters, and ductwork, located beyond the purge system isolation valves against loss of function from the environment created by the escaping air and steam.	N/A. The purge system has no safety-related fans, filters or ductwork beyond the isolation valves. See also Reference 11 of Section 18.2.18.
B.5.c	
An analysis of the reduction in the containment pressure resulting from the partial loss of containment atmosphere during the accident for ECCS backpressure determination.	Complies. See Section 6.2.1.5.8.
B.5.d	
The maximum allowable leak rate of the purge isolation valves should be specified on a case-by-case basis giving appropriate consideration to valve size, maximum allowable leakage rate for the containment (as defined in Appendix J to 10 CFR Part 50), and where appropriate, the maximum allowable bypass leakage fraction for dual containments.	Complies. See the Bases for Technical Specification Surveillance Requirement 3.6.3.7.

TABLE 9.4-14 DESIGN DATA FOR THE DIESEL GENERATORS BUILDING VENTILATION SYSTEM COMPONENTS*

I.	Diesel Generators Building Ventilation Supply Fans	
	Quantity	2
	Type	Vaneaxial
	Airflow, cfm each	120,000
	Static pressure, in. w.g.	2.25
	Motor horsepower, hp	100
	Design codes and standards	
	Fan	AMCA
	Motor	IEEE-323
	Seismic design	Category I
II.	Diesel Generators Building Unit Heaters	
	A. Quantity	4
	Heating capacity, kW each	30
	Type	Electric
	Design standards	NEC, UL
	Seismic design	Non-Category I
	B. Quantity	4
	Heating capacity, kW each	40
	Type	Electric
	Design standards	NEC, UL
	Seismic design	Non-Category I

* NOTE: Design parameters shown in Table 9.4-14 represent the values specified in procurement specifications. Minor variations in performance characteristics may exist between individual components. Adequate margin is maintained to ensure components can perform their design function.

TABLE 9.4-15 SINGLE-FAILURE ANALYSES - DIESEL GENERATOR BUILDING VENTILATION SYSTEM

Component	Malfunction	Consequences
Inlet damper	Fails to open; loss of air cooling	Loss of one system; redundant system is available for cooling the redundant diesel.
Recirculation damper	Fails to open during winter conditions; subfreezing air being supplied into diesel generator room	Low-temperature cutouts on ventilation system isolate the fans.
Fans	Fails to start	Loss of one system; redundant system is available for cooling the redundant diesel.

TABLE 9.4-16 ESSENTIAL SERVICE WATER PUMPHOUSE AND UHS ELECTRICAL EQUIPMENT ROOM VENTILATION SYSTEM COMPONENTS*

I.	Site Ambient Design Temperature	
	Summer	95°F
	Winter	6°F
II.	ESW Pumphouse Supply Fans	
	Quantity, per room	1
	Air flow, cfm each	30,000
	Static pressure, in. w.g. each	1.85
	Motor horsepower, hp each	15.0
	Type	Vaneaxial
	Design Codes and Standards	
	Fan	MS
	Motor	IEEE-323
	Seismic Design	Category I
III.	ESW Pumphouse Unit Heaters	
	Quantity,	6
	Heating capacity, kW each	15
	Type	Electric
	Quantity,	2
	Heating capacity, kW each	25
	Type	Electric
	Design Codes and Standards	MS
	Seismic Design	Non-Category I
IV.	UHS Electrical Equipment Room Supply Fans	
	Quantity, per room	1
	Air flow, cfm each	3500
	Static pressure, in. w.g. each	2.0
	Motor horsepower, hp each	3
	Type	Centrifugal
	Design Codes and Standards	
	Fan	MS
	Motor	IEEE-323
	Seismic Design	Category I
V.	UHS Electrical Equipment Room Unit Heaters	
	Quantity, per room	2
	Heating capacity, kW each	20
	Type	Electric
	Design Codes and Standards	MS
	Seismic Design	Non-Category I

TABLE 9.4-16 (Sheet 2)

* NOTE: Design parameters shown in Table 9.4-16 represent the values specified in procurement specifications. Minor variations in performance characteristics may exist between individual components. Adequate margin is maintained to ensure components can perform their design function.

TABLE 9.4-17 SINGLE-FAILURE ANALYSES - ESSENTIAL SERVICE WATER PUMPHOUSE AND UHS ELECTRICAL EQUIPMENT ROOM VENTILATION SYSTEMS

Component	Malfunction	Consequences
Inlet damper	Fails to open; loss of air cooling	Loss of one system; redundant system is available for cooling the redundant pump.
Discharge damper	Fails to open; loss of discharge air	Loss of one system; redundant system is available for cooling the redundant pump.
Fans	Fails to start	Loss of one system; redundant system is available for cooling the redundant pump.
Thermostats	Fails to operate	Loss of one system; redundant system is available for cooling the redundant pump.

TABLE 9.4-18 DESIGN DATA FOR PLANT HEATING SYSTEM COMPONENTS*

I.	Main Hot Water Pumps	
	Quantity	2
	Type	Centrifugal
	Capacity, gpm each	918
	Head, ft of water, each	150
	Motor horsepower, each	60
	Casing material	Cast iron
	Impeller material	Bronze
	Design standards	
	Pump	MS
	Motor	NEMA
II.	Secondary Loop Hot Water Pumps	
	Quantity	8
	Type	In line
	Hot water flow rate, gpm	11-130*
	Head, ft of water	12-15*
	Motor horsepower	0.25-1*
	Casing material	Cast iron
	Impeller material	Bronze
	Design standards	MS
III.	Heat Exchanger	
	Hot water temperature in, °F	158
	Hot water temperature out, °F	198
	Inlet steam pressure, psig	25
	Steam temperature in, °F	267
	Condensate temperature out, °F	212
	Steam flow rate, lb/hr	19,660
	Design pressure, psig	
	Tube side	150
	Shell side	150
	Tube material	90-10 Cu-Ni, SB-111
	Shell material	Carbon steel, SA-285
	Fouling factor	0.0014
	Design code	ASME Section VIII

* Indicates range for eight pumps.

TABLE 9.4-18 (Sheet 2)

IV.	Hot Water Expansion Tank	
	Quantity	1
	Capacity, gal.	400
	Operating pressure, psig	30
	Design pressure, psig	125
	Material	Carbon steel Shell: SA-414G Heads: SA-414F
	Design Code	ASME Section VIII

* NOTE: Design parameters shown in Table 9.4-18 represent the values specified in procurement specifications. Minor variations in performance characteristics may exist between individual components. Adequate margin is maintained to ensure components can perform their design function.

TABLE 9.4-19 DESIGN DATA FOR CENTRAL CHILLED WATER SYSTEM COMPONENTS*

I.	Chilled Water Pumps	
	Quantity	2
	Type	Centrifugal
	Motor horsepower, each	75
	Capacity, gpm, each	720
	Head, ft each	227
	Casing material	Cast iron
	Impeller material	Bronze
	Design standards	
	Pump	MS
	Motor	NEMA
II.	Central Chillers	
	Quantity	2
	Type	Centrifugal
	Capacity, tons, each	540
	Refrigerant	R12
	Design code	ASME Section VIII
	A. Condenser	
	Design pressure, psig	
	Tube side	200
	Shell side	150
	Entering water Temperature, °F	95
	Condenser water flow, gpm	1,500
	Fouling factor (service water)	0.002
	Tube material	90/10 copper-nickel
	Shell material	Carbon steel
	B. Compressor	
	kW, input	691
	Type	Centrifugal, hermetic
	C. Evaporator	
	Design pressure, psig	
	Tube side	150
	Shell side	150
	Chilled water entering temperature, °F	62
	Chilled water leaving temperature, °F	44
	Chilled water flow, gpm	720
	Fouling factor (chilled water)	0.0005
	Tube material	Copper

TABLE 9.4-19 (Sheet 2)

	Shell material	Carbon steel
III.	Chilled Water Expansion Tank	
	Quantity	1
	Design pressure, psig	50
	Operating pressure, psig	35
	Design capacity, gal	315
	Material	Carbon steel
	Design code	ASME Section VIII

* NOTE: Design parameters shown in Table 9.4-19 represent the values specified in procurement specifications. Minor variations in performance characteristics may exist between individual components. Adequate margin is maintained to ensure components can perform their design function.

9.5 OTHER AUXILIARY SYSTEMS

9.5.1 FIRE PROTECTION SYSTEM

The following information provides a general discussion of the fire protection program and systems at the Callaway Plant.

The fire protection program is based on the NRC requirements and guidelines, Nuclear Electric Insurance Limited (NEIL) Property Loss Prevention Standards and related industry standards. With regard to NRC criteria, the fire protection program meets the requirements of 10 CFR 50.48(c), which endorses, with exceptions, the National Fire Protection Association's (NFPA) Standard 805, "Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants - 2001 Edition" (NFPA 805). Callaway Plant has further used the guidance of NEI 04-02, "Guidance for Implementing a Risk-Informed, Performance-Based Fire Protection Program under 10 CFR 50.48(c)," as endorsed by Regulatory Guide 1.205, "Risk-Informed, Performance Fire Protection for Existing Light-Water Nuclear Power Plants."

Adoption of NFPA 805, “Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants - 2001 Edition” in accordance with 10 CFR 50.48(c) serves as the method of satisfying 10 CFR 50.48(a) and General Design Criterion (GDC) 3. Prior to adoption of NFPA 805, General Design Criterion 3, "Fire Protection," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Licensing of Production and Utilization Facilities," was followed in the design of safety and non-safety related structures, systems, and components (SCCs), as required by 10 CFR 50.48(a).

NFPA 805 does not supersede the requirements of GDC 3, 10 CFR 50.48(a), or 10 CFR 50.48(f). Those regulatory requirements continue to apply. However, under NFPA 805, the means by which requirements are met may be different than under 10 CFR 50.48(b). Specifically, whereas GDC 3 refers to SSCs important to safety, NFPA 805 identifies fire protection systems and features required to meet the Chapter 1 performance criteria through the methodology in Chapter 4 of NFPA 805. Also, under NFPA 805, the 10 CFR 50.48(a)(2)(iii) requirement to limit fire damage to SSCs important to safety so that the capability to safely shut down the plant is satisfied by meeting the performance criteria in Section 1.5.1 of NFPA 805.

The term "safe shutdown" is used throughout the FSAR (e.g., FSAR Section 5.4A.1). For the purposes of the fire protection hazards analysis, safe shutdown is defined as "safe and stable" in NFPA 805. Table 9.5.1-3 describes the approach for achieving safe and stable condition in the event of a fire.

In FSAR Section 3B the process of conducting a hazards analysis is described. For the Fire Protection Program the fire hazards analysis is the Fire Safety Analysis as described in Section 9.5.1.3.

Dry cask storage operations performed in the Fuel Building at Callaway must satisfy 10 CFR 72 fire protection requirements along with applicable NFPA 805 fire protection requirements described in this chapter. For dry cask storage operations performed outside the power block, refer to M-2020-09013, “Evaluation of Plant Hazards at Callaway Energy Center”; M-2020-09014, “Evaluation of Combined Effect of HI-PORT and VCT Fires on HI-TRAC at Callaway”; and the 10 CFR 72.212 Evaluation Report.

9.5.1.1 Design Bases

9.5.1.1.1 Safety Design Bases

Structures, systems, and components important to safety are designed and located to minimize the fire hazard consistent with other safety requirements. Noncombustible and heat resistant materials are used wherever practical throughout the unit to minimize the fire intensity in any combustion zone. This requirement is in compliance with 10 CFR 50, General Design Criterion 3, “Fire Protection.”

The basic fire protection for safety-related items is achieved by fire inception avoidance and through remote separation of systems serving the same safety function or by fire barriers between such installations. Therefore, except for an associated containment penetration, the Fire Protection System (FPS) is not a safety-related system.

Therefore, except for an associated containment penetration, the FPS is not a safety-related system.

All DCSS components are classified as Important to Safety (ITS) or Not Important to Safety (NITS) as described in Callaway’s Operating Quality Assurance Manual, based upon their safety function. Fire protection for DCSS components is achieved by fire inception avoidance and, as much as possible, remote separation from potential fire sources.

SAFETY DESIGN BASIS ONE - The containment isolation valves in the FPS are selected, tested, and located in accordance with the requirements of 10 CFR 50, Appendix A, General Design Criteria 54 and 56 and 10 CFR 50, Appendix J, Type C testing.

9.5.1.1.2 NFPA 805 Performance Criteria

The design basis for fire protection at Callaway Plant is based on fire protection, nuclear safety objectives, and radiological release objectives put in effect under 10 CFR 50.48(c) which endorses, with exceptions, the National Fire Protection Association's 805, "Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants - 2001 Edition." NFPA 805, Chapter 1 contains the following nuclear safety and radiological release performance criteria:

Nuclear Safety Performance Criteria. Fire protection features shall be capable of providing reasonable assurance that, in the event of a fire, the plant is not placed in an unrecoverable condition. To demonstrate this, the following performance criteria shall be met:

a. Reactivity Control. Reactivity control is capable of inserting negative reactivity to achieve and maintain subcritical conditions. Negative reactivity inserting will occur rapidly enough such that fuel design limits are not exceeded.

b. Inventory and Pressure Control. With fuel in the reactor vessel, head on and tensioned, inventory and pressure control is capable of controlling coolant level such that subcooling is maintained and fuel clad damage as a result of a fire is prevented.

c. Decay Heat Removal. Decay heat removal is capable of removing sufficient heat from the reactor core or spent fuel such that fuel is maintained in a safe and stable condition.

d. Vital Auxiliaries. Vital auxiliaries are capable of providing the necessary auxiliary support equipment and systems to assure that the systems required under (a), (b), (c), and (e) are capable of performing their required nuclear safety function.

e. Process Monitoring. Process monitoring is capable of providing the necessary indication to assure the criteria addressed in (a) through (d) have been achieved and are being maintained.

Radioactive Release Performance Criteria. Radiation release to any unrestricted area due to the direct effects of fire suppression activities (but not involving fuel damage) shall be as low as reasonably achievable and shall not exceed applicable 10 CFR, Part 20, Limits.

Chapter 2 of NFPA 805 establishes the process for demonstrating compliance with NFPA 805.

Chapter 3 of NFPA 805 contains the fundamental elements of the fire protection program and specifies the minimum design requirements for fire protection systems and features.

Chapter 4 of NFPA 805 establishes the methodology to determine the fire protection systems and features required to achieve the performance criteria outlined in NFPA 805 Section 1.5. The methodology shall be permitted to be either deterministic or performance-based. Deterministic requirements shall be "deemed to satisfy" the performance criteria, defense-in-depth, and safety margin and require no further engineering analysis. Once a determination has been made that a fire protection system

or feature is required to achieve the performance criteria of NFPA 805 Section 1.5, its design and qualification shall meet the applicable requirement of Chapter 3.

9.5.1.1.3 Defense-in-Depth

The Callaway Plant fire protection program is focused on protecting the safety of the public, the environment, and plant personnel from a plant fire and its potential effect on safe reactor operations. The fire protection program is based on the concept of defense-in-depth.

Defense-in-depth shall be achieved when an adequate balance of each of the following elements is provided:

1. Preventing fires from starting,

2. Rapidly detecting fires and controlling and extinguishing promptly those fires that do occur, thereby limiting fire damage,

3. Providing an adequate level of fire protection for structures, systems, and components important to safety, so that a fire that is not promptly extinguished will not prevent essential plant safety functions from being performed.

9.5.1.1.4 Performance Objectives

10 CFR 50.48(c) through NFPA 805 provides performance objectives for Callaway Plant as follows:

Nuclear Safety Objectives for the plant, in the event of a fire during any operational mode and plant configuration, are as follows:

a. Reactivity Control shall ensure the capability of rapidly achieving and maintaining subcritical conditions.

   (a) (1) Fuel Cooling shall ensure the capability of achieving and maintaining decay heat removal and inventory control functions.

   (a) (2) Fission Product Boundary shall ensure the capability of preventing fuel clad damage so that the primary containment boundary is not challenged.

b. Radioactive Release Objectives shall ensure either of the following objectives shall be met during all operational modes and plant configurations.

   (b) (1) Containment integrity is capable of being maintained.

(b) (2) The source term is capable of being limited.

9.5.1.1.5 Codes of Record

The codes, standards and guidelines used for the design and installation of plant fire protection systems are as follows (for specific applications and interpretations of codes refer to design documents such as specifications and drawings):

a. Nuclear Energy Liability Property Insurance Association (NEL-PIA). April 1976. NEL-PIA is now American Nuclear Insurers (ANI).

b. American Society for Testing Materials (ASTM):

A-120-1973, Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses

D 3286-1973, Standard Test Method for Gross Calorific Value of Coal and Coke by the Isoperibol Bomb Calorimeter

E-84-1976, Test for Surface Burning Characteristics of Building Materials

E-119-1980, Standard Test Method for Fire Test of Building Construction and Materials

c. Factory Mutual Research (FM) Fire Protection Equipment Approval Guide

d. Institute of Electrical and Electronic Engineers (IEEE)

Std. 317-1976, IEEE Standard for Electrical Penetration Assemblies in Containment Structures for Nuclear Power Generating,

Std. 383-1974, Standard for Type Test of Class 1E Electrical Cables, Field Splices, and Connections for Nuclear Power Generating Stations,

Std. 384-1974, Criteria for Separation of Class 1E Equipment and Criteria,

Std. 634-1978, Standard Cable Penetration Fire Stop Qualification Test

e. UL (Underwriters Laboratories)

UL-790-1978, Standard Test Methods for Fire Tests of Roof Coverings,

UL-10B-1974, Fire Tests of Door Assemblies

f. Occupational Safety and Health Standards (OSHA), October 1972

g. National Fire Protection Association (NFPA)

NFPA 10-1975: Standard for Portable Fire Extinguishers

NFPA 12A-1973: Standard on Halon 1301 Fire Extinguishing Systems

NFPA 13-1976: Standard for the Installation of Sprinkler Systems

NFPA 13-1983: Standard for the Installation of Sprinkler Systems

NFPA 14-1976: Standard for the Installation of Standpipe, Private Hydrant and Hose Systems

NFPA 20-1974: Standard for the Installation of Stationary Pumps for Fire Protection

NFPA 22-1974: Standard for Water Tanks for Private Fire Protection

NFPA 24-1973: Standard for the Installation of Private Fire Service Mains and their Appurtenances

NFPA 30-1973: Flammable and Combustible Liquids Code

NFPA 50A-1973: Standard for Gaseous Hydrogen Systems at Consumer Sites

NFPA 51B-1971: Standard for Fire Prevention During Welding, Cutting and Other Hot Work

NFPA 72D-1975: Standard for the Installation, Maintenance and use of Proprietary Protective Signaling Systems for Watchman, Fire Alarm and Supervisory Service

NFPA 72E-1978: Automatic Fire Detectors

NFPA 80-1977: Standard for Fire Doors and Fire Windows

NFPA 80A-1996: Recommended Practice for Protection of Buildings from Exterior Fire Exposures

NFPA 90A-1976: Standard for the Installation of Air-Conditioning and Ventilating Systems

NFPA 241-2000: Standard for Safeguarding Construction, Alternation, and Demolition Operations

NFPA 600-2000: Standard on Industrial Fire Brigades

Callaway Plant Calculation KC-27, "NFPA Code Conformance Review," documents the level of compliance to the NFPA Standards listed above for plant areas required to meet the performance criteria of NFPA 805, Section 1.5.

Callaway Plant Calculation KC-43, "Code Compliance Evaluation NFPA 805, Performance Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants - 2001 Edition," documents the Callaway Plant compliance to the NFPA 805 Standard - 2001 Edition.

9.5.1.2 System Description

NFPA 805 establishes the methodology to determine the fire protection systems and features required to achieve the performance criteria outlined in NFPA 805, Section 1.5. The methodology shall be permitted to be either deterministic or performance-based. Deterministic requirements shall be "deemed to satisfy" the performance criteria and require no further engineering analysis. Once a determination has been made that a fire protection system or feature is "required" to achieve the performance criteria of NFPA 805, Section 1.5, its design and qualification shall meet the applicable requirements of NFPA 805, Chapter 3.

Dry cask storage operations performed in the Fuel Building at Callaway must satisfy 10 CFR 72 fire protection requirements along with applicable NFPA 805 fire protection requirements described in this chapter. For dry cask storage operations performed outside the power block, refer to M-2020-09013, “Evaluation of Plant Hazards at Callaway Energy Center”; M-2020-09014, “Evaluation of Combined Effect of HI-PORT and VCT Fires on HI-TRAC at Callaway”; and the 10 CFR 72.212 Evaluation Report.

9.5.1.2.1 Required Active Systems

Required active fire protection systems are identified in Callaway Plant Calculation KC-43, which contains Callaway Table B-1 - Transition of Fundamental FP Program and Design Elements (NFPA 805 Chapter 3). Required active fire suppression sprinkler systems are also identified in the fire area Fire Safety Analysis (FSA). The required systems compliance with applicable NFPA codes is documented in Callaway Plant Calculation KC-27. The fire suppression and detection systems are depicted in plant P&ID's M-22KC01 thru M-22KC08.

9.5.1.2.2 Required Passive Systems and Features

Required passive fire protection systems and features are described in Callaway Plant Calculation KC-43, which contains Callaway Table B-1 - Transition of Fundamental FP Program and Design Elements (NFPA 805 Chapter 3). Required passive fire protection systems and features are also identified in the fire area Fire Safety Analysis (FSA). The required passive systems and features compliance with applicable NFPA codes is

documented in Callaway Plant Calculation KC-27. The fire area boundaries and separation zones are shown in plant drawings A-2801 thru A-2820.

9.5.1.2.3 Definition of “Power Block” Structures

There are several versions of the definition of power block used at Callaway Plant as it applies to various plant programs (examples are given in FSAR section 1.1.2). The term "Power Block," as defined here is only applicable to the scope of 10 CFR 50.48(c) and NFPA 805 and applicable to the Callaway Plant Fire Protection Program.

NFPA 805, paragraph 1.6.46, defines the power block as "structures that have equipment required for nuclear plant operations." Power block equipment includes all the structures, systems, and components (SSCs) required for the safe and reliable operation of the station. It includes all safety-related and balance-of-plant systems and components required for the operation of the station. This equipment does not include buildings or structures that support station staff, such as offices or storage structures, or the HVAC and support systems focused only on habitability of those structures.

Table 9.5.1-1 identifies the structures included in the Callaway Plant fire protection program in accordance with 10 CFR 50.48(c) and NFPA 805 and subject to its requirements. Callaway Plant Calculation KC-43 also contains the description of power block structures.

9.5.1.2.4 Fire Protection Water Supply

The Fire Protection System (FPS) water supply design complies with NFPA 805 as described in Callaway Plant Calculation KC-43.

The FPS water supply consists of two separate water tanks interconnected with three fire pumps that discharge into a 14-inch underground yard loop which feeds the individual power block structures. FPS yard loop pressure and volume are maintained by an air compressor/air accumulator (pressure) and jockey fire pump (volume).

The two separate FPS 300,000 gallon maximum capacity water storage tanks are filled from the clarified water supply or deep well. The tanks are interconnected to a common header so that the three fire pumps can take suction from either/or both of the tanks. Check valves are provided so that a leak in one tank or its supply piping does not cause both tanks to drain. The tanks have a local connection for filling and supply if necessary. Freeze protection is provided for the tanks and any piping exposed to freezing conditions. The FPS water tanks maintain a volume of 260,000 gallons (tank water level 31 feet) each to remain functional. The tanks are normally maintained at a nominal water level of 34 feet. Each tank is provided with local level indication and an automatic make up capability of 600 gpm that initiates when the tank level reaches a water level of 33.0 feet. The tanks are provided with level indication that alarms at tank level 31.5 ft. and a low temperature alarm at 39 degrees F, each of which alarms in the Main Control Room (MCR).

The FPS fire pumps consist of three 50 percent capacity pumps rated for 1500 gpm. Two pumps are diesel-driven and one pump is electric motor driven with power supplied from a nonsafety-related power supply. Any two of the three fire pumps are capable of providing the design demand flow required for the FPS. The fire pumps are arranged to start automatically when the underground yard loop pressure drops below 125 psi. The motor-driven pump starts first at 130 psi followed by diesel-driven fire pump A at 125 psi and then diesel driven fire pump B at 120 psi. The fire pump controllers contain a sequential timing device to prevent the simultaneous start of the fire pumps. The diesel driven pumps also start on a loss of AC power to their battery chargers and the motor driven fire pump. The fire pumps are stopped locally only. Manual start controls are provided at each pump via a local controller and in the Main Control Room. Fire pump alarms are provided locally and in the Main Control Room and include controller not in Auto Mode (diesel driven pumps only), pump running, power failure (electric motor driven pump only) and failure-to-start indicator. In addition, each diesel engine has a malfunction alarm.

The yard loop pressure is maintained by an air accumulator charged by a local dedicated air compressor. The air compressor maintains the accumulator tank pressure between 163 psi and 167 psi. A jockey pump is provided to maintain normal system volume when the fire pumps are not in operation. The motor-driven jockey pump takes suction from the fire water tank header and maintains accumulator tank level at approximately 50%. Jockey fire pump alarms for excessive running and malfunction are provided in the Main Control Room.

The 14" diameter unlined steel underground yard loop around the power block has feeds to each power block building. The underground yard loop is sectionalized by means of Post Indicating Valves (PIVs) to isolate portions of the main for maintenance or repair without shutting off the entire system. Two-way hydrants located approximately every 250 feet on the underground yard loop and the lateral to each hydrant from the fire main is furnished with a curb valve.

9.5.1.3 Safety Evaluation (Fire Safety Analyses)

As part of the NFPA 805 fire protection program, a fire safety analysis (FSA) document is provided for each plant fire area. The FSA's are comprised of Callaway Plant calculations, KC-81 thru KC-161. The purpose of the FSA is to demonstrate the achievement of the nuclear safety and radioactive release performance criteria of NFPA 805 as required by 10 CFR 50.48(c). The FSA's analysis also documents the results of risk-informed, performance-based evaluations, and serves as the design basis document (DBD) described in NFPA 805, Section 2.7.1.2. The FSA provides evaluations associated with non-compliances from the pre-NFPA 805 transition licensing basis that have been analyzed and approved during NFPA 805 transition (transition risk evaluations). Changes to the post-transition fire protection program have been analyzed and approved per the requirements of the Callaway Plant fire protection license condition (post-transition change evaluations) described in License Condition 2.C.5.

The ISFSI facility fire area and ISFSI route fire area are both located outside the power block on the 2000' elevation approximately 500 feet East of the power block of the Fuel Building in an expansion of the plant Protected Area (PA). Dry cask storage operations must satisfy 10 CFR 72 fire protection requirements along with applicable NFPA 805 fire protection requirements described in this chapter. For dry cask storage operations performed outside the power block, refer to M-2020-09013, "Evaluation of Plant Hazards at Callaway Energy Center"; M-2020-09014, "Evaluation of Combined Effect of HI-PORT and VCT Fires on HI-TRAC at Callaway"; and the 10 CFR 72.212 Evaluation Report.

There is no safe shutdown equipment within the ISFSI fire area or the ISFSI route fire area.

The following information is documented on a fire area basis in each fire safety analysis calculation:

9.5.1.3.1 Documentation of existing fire area construction, area specific boundary non-rated features if applicable, identification of detection and suppression systems including identification of those which are required systems, identification of manual suppression capabilities and the basic fire response strategy for the area, ventilation, and identification of credited features specific to the area such as tray covers, floor curbs, and embedded conduits. It may also include suppression system assumptions and inadvertent actuation or mal-operation evaluations.

9.5.1.3.2 Documentation Identification of significant fire hazards in the fire area based on the NFPA 805 approach to analyze the plant from an ignition source and fuel package perspective.

9.5.1.3.3 Documentation Summary of Nuclear Safety Capability Assessment (NSCA) compliance strategies. This is the result of the NEI 04-02 Table B-

3 review of the Safe Shutdown Analysis. The fire area B-3 table is included in the FSA.

9.5.1.3.4 Documentation Summary of Non-Power Operations Modes compliance strategies.

9.5.1.3.5 Documentation Summary of Radioactive Release compliance strategies.

9.5.1.3.6 Documentation Fire Probabilistic Risk Assessment (PRA) summary of results. This is based on the results from the plant Fire PRA.

9.5.1.3.7 Documentation Risk-informed, performance-based evaluations if needed for the performance based approach.

9.5.1.3.8 Documentation Summary of Defense-in-Depth strategy for each fire area.

9.5.1.3.9 Documentation Key analysis assumptions (required systems and features) that are to be included in the NFPA 805 monitoring program.

9.5.1.3.10 Documentation Conclusions relative to NFPA 805 compliance.

Individual risk evaluations, as needed, are documented in the FSA performed for each fire area. The format for the FSA follows the requirements for preparation and control of design analyses and calculations.

9.5.1.4 Tests and Inspections

9.5.1.4.1 Surveillance Requirements

Guidance for the operability, action, and surveillance requirements for fire protection systems required to meet either the performance or deterministic requirements of NFPA 805 is provided in the Plant Operating procedures APA-ZZ-00700, "Fire Protection Program," and APA-ZZ-00703, "Fire Protection Operability and Surveillance Requirements," and supersedes the original plant Technical Specifications. Required systems are identified by fire area and required application in the FSA for each fire area.

The inspection, testing and maintenance frequencies for required systems are based on performance-based surveillance frequencies established as described in Electric Power Research Institute (EPRI) Technical Report TR-1006756, "Fire Protection Surveillance Optimization and Maintenance Guide for Fire Protection Systems and Features," and evaluated in Callaway Plant Calculation KC-162, "Performance Based Fire Protection Surveillance Frequency Program."

9.5.1.4.2 Monitoring Program

Section 2.6 of NFPA 805 states:

"A monitoring program shall be established to ensure that the availability and reliability of the fire protection systems and features are maintained and to assess the performance of the fire protection program in meeting the performance criteria. Monitoring shall ensure that the assumptions in the engineering analysis remain valid."

Callaway Calculation KC-43 contains the description of the compliance with the NFPA 805, Section 2.6 requirements. High Safety Significant fire protection systems and features are established in Callaway Calculation KC-163. The monitoring program is described in procedure EDP-ZZ-01101, "Fire Protection Monitoring Program Procedure."

9.5.1.5 Personnel Qualification and Training

9.5.1.5.1 Fire Brigade

A fully staffed, trained, and equipped firefighting force shall be available at all times to control and extinguish all fires on site. This force shall have a minimum complement of five persons on duty and during every shift, the brigade leader and at least two brigade members shall have sufficient training and knowledge of nuclear safety systems to understand the effects of fire and fire suppressants on nuclear safety performance criteria. On-site firefighting capability compliance with the requirements of NFPA 805 is described Callaway Plant Calculation KC-43 which contains Table B-1 - Transition of Fundamental FP Program and Design Elements (NFPA 805 Chapter 3). Implementation and administrative controls for the Fire Brigade Program (i.e., training, qualifications, and drills) at Callaway Plant are contained in procedures APA-ZZ-00743, "Fire Team Organization and Duties," and FPP-ZZ-00009, "Fire Protection Training Program." Callaway Plant calculation KC-27, "NFPA Code Conformance Review," documents the level of compliance to NFPA 600, “Standard on Industrial Fire Brigades.” Fire Pre-Plans are available for use by the fire brigade and other plant staff responders. The Fire Pre-Plan Manual is a controlled document.

9.5.1.5.2 Fire Protection Management

The Callaway Plant Fire Protection Program is described in procedure APA-ZZ-00700, "Fire Protection Program." The Fire Protection Program procedure along with other site documents, provide the management policy and program direction and defines the responsibilities of those individuals responsible for the program implementation. The Fire Protection Program procedure establishes the criteria for an integrated combination of components, procedures, and personnel to implement all fire protection program activities. The program procedure defines management authority and responsibilities and establishes the general policy for the site fire protection program. The Fire Protection Program procedure designates the senior management position with immediate authority and responsibility for the fire protection program, along with designation of the position responsible for the daily administration and coordination of the fire protection program and its implementation. Qualifications for individuals responsible for administration of a fire protection program are discussed in Callaway Plant Calculation KC-43 which contains Table B-1 - Transition of Fundamental FP

Program and Design Elements (NFPA 805 Chapter 3). This includes a requirement that individuals responsible for day-to-day administration of the fire protection programs be experienced in nuclear power plant fire protection, with a qualified fire protection engineer meeting Society of Fire Protection Engineers (SFPE) member grade qualifications. The term "qualified FP Engineer" when used means a fire protection engineer meeting Society of Fire Protection Engineers (SFPE) member grade qualifications.

The Fire Protection Program procedure defines the fire protection interfaces with other organizations and assigns responsibilities for the coordination of activities. In addition, the Fire Protection Program procedure identifies the various plant positions having the authority for implementing the various areas of the fire protection program. The Fire Protection Program procedure also identifies the appropriate Authority Having Jurisdiction (AHJ) for various site areas and portions of the fire protection program. Procedures have been established for implementation of the various facets of the fire protection program in accordance with applicable regulatory and industry requirements and guidance as committed to in Table B-1.

9.5.1.6 Configuration and Quality Assurance

9.5.1.6.1 Configuration Control

Callaway Calculation KC-43 identifies the compliance methodology for the quality requirements of Chapter 2 and the programmatic requirements of Chapters 2 and 3 of NFPA 805.

9.5.1.6.2 Quality Assurance

Background

The Fire Protection Quality Assurance (QA) program was developed as a graded QA program under the management of the Union Electric Nuclear Oversight organization and it was based on Quality Assurance criteria identified in NRC letter and Attachment 6 on August 29, 1977, signed by D. B. Vassallo. The Fire Protection QA Program was applied to portions of the fire protection program which protect safety related areas. The Fire Protection QA program was called "augmented quality special scope" and consisted of a subset of the 18 QA criteria applicable under 10 CRF 50 Appendix B specifically only 10 of the criterion were applied to Fire Protection special scope program. The description of this program was contained in FSAR SP Section Table 9.5A. Initiation of the original design phase and original equipment procurement commenced before issuance of the FP QA program. Further activities were not performed under the guidance of criteria 1 and 3 and had proceeded to a point where modifying ongoing design and procurement to conform to the scope outlined in Appendix A was not feasible. The activities related to these two criteria were performed under standard engineering and procurement methods that were considered acceptable by Union Electric. Additionally, the design was reviewed by Union Electric's engineering staff and

by American Nuclear Insurers (ANI). A March 20, 1980 NRC letter questioned this alternate method of complying with Criteria 1 and 3, and Union Electric revised its position accordingly. For design documents and procurement related documents that were prepared during the interim period subsequent to the Branch Technical Position and prior to June 1, 1980, an independent review by knowledgeable personnel was performed. Verification of fire protection system design and component material performance and integrity was accomplished, where applicable, by preoperational and startup testing. These tests were performed and documented in accordance with written and approved test procedures and were subject to the Quality Assurance Program as outlined below.

NFPA 805 FP QA Program

During transition of the FP program to NFPA 805 the existing FP Special Scope program was carried forward with minor changes. Because FSAR SA Section 9.5.1 and its tables were incorporated into the FSAR SP, the FP QA program description was moved herein. A change to the scope of the covered fire protection program, systems and features was made. The original FP QA program applied to FP program systems and features that protected safety related areas. The NFPA 805 FP QA program applies to those FP program systems and features that are credited (required) to meet the performance requirements of NFPA 805 Chapters 3 and 4. The FP QA program inspection, and test and test control referenced to FSAR SA Section 9.5.1.1.3 Codes and Standards and that reference was revised to FSAR SP Section 9.5.1.1.5, Codes of Record.

The FP Special Scope QA program is based on applicable sections of the Operating Quality Assurance Manual (OQAM). Each section either endorses or is derived from its respective OQAM section. Training of personnel who maintain, inspect and test the fire protection system is as described in the OQAM, Section 2.0.

The existing line organizations described in Section 1.0 of the OQAM are responsible for compliance with this program. No separate organization is required to implement the requirements.

9.5.1.6.2.1 Design Control and Procurement Document Control

Design controls for fire protection are as described in OQAM, Section 3.0. Procurement document controls shall be established to assure procurement documents adequately state the quality and technical requirements. Special scope requirements are specified in the procurement documents as appropriate (e.g. receipt inspection criteria, qualification testing requirements) and plant procedures. Measures to control the issuance of documents are as described in the OQAM, Section 6.0.

9.5.1.6.2.2 Instructions, Procedures and Drawings

Measures for instructions, procedures, and drawings are as described in the OQAM, Section 5.0. Fire protection administrative control procedures, instructions, and drawings

related to design, modification, installation, inspection, test, and maintenance are reviewed to assure appropriate fire protection requirements are included such as: precautions; control of ignition sources and combustibles; and provisions for backup fire protection, if the activities require disabling a fire protection system. The installation or application of penetration seals and fire retardant coatings are performed in accordance with plant procedures or manufacturer's instructions by personnel knowledgeable of these instructions.

9.5.1.6.2.3 Control of Purchased Material, Equipment, and Services

Purchased material, equipment and services shall conform to procurement documents as prescribed in OQAM Section 4.0. In addition, the following controls are implemented:

a. Suppliers of fire protection materials and equipment are from vendors commercially qualified to provide the material and equipment.

b. Inspection or performance testing is conducted to verify that material, equipment, and services pertaining to the fire protection system conform to procurement documents. Inspections shall occur as receipt inspections, or installation inspections, or both as appropriate.

9.5.1.6.2.4 Inspection

Maintenance or modifications to the Fire Protection System (FPS) are subject to inspection to assure conformance to design and installation requirements. Such inspections may occur as receipt inspections or installation inspections, or both, as appropriate. The installation of the portions of the fire protection system where performance cannot be verified through preoperational tests, such as penetrations seals, fire retardant coatings, cable routing, and fire barriers shall be inspected. Inspections are performed by individuals who are knowledgeable of fire protection design and installation requirements. These inspections are performed in accordance with procedures or checklists and shall include, as applicable, the following:

a. Identification of items/activities to be inspected.

b. Individuals/organizations responsible to perform inspections.

c. Referenced design documents and acceptance criteria.

d. Identification of inspection method.

e. Documentation requirements.

f. Inspection results, inspection signoff.

The fire protection systems are installed by a contractor qualified and experienced in the work. Tests and inspection of this installation are performed in accordance with the requirements of the agencies listed in Section 9.5.1.1.5 and as described in Callaway Calculations KC-27 and KC-162. For those materials subject to degradation (such as fire stops, seals and fire retardant coatings), periodic visual inspections are performed to assure they have not deteriorated or been damaged. Periodic inspections and/or tests are performed of fire protection systems, emergency breathing and auxiliary equipment to assure acceptable condition of these items. Such inspections and/or tests are performed during the operating phase of the plant.

9.5.1.6.2.5 Test and Test Control

Section 9.5.1.6.2.4 describes the program by which preoperational testing shall be performed to verify conformance with design and system performance. Written test procedures for preoperational tests shall incorporate the requirements and acceptance limits contained in applicable design documents. System tests are supplemented, where appropriate, by prototype commercial performance testing specified in procurement documents and performed in accordance with applicable industry standards. The OQAM, Section 11.0 describes the program to verify conformance with design following modification, repair or replacement of portions of the FPS. Also discussed is a program of periodic tests to verify system readiness requirements.

9.5.1.6.2.6 Inspection, Test and Operating Status

Measures shall exist to identify items that have satisfactorily passed required preoperational tests and inspections. Identification shall consist of tags, labels or other means of control, such as recording in electronic job reports.

9.5.1.6.2.7 Non-Conforming Items

Items that do not conform to specific requirements are identified during inspection and/or tests. Controls for nonconforming material and equipment are as described in the OQAM, Section 15.0.

9.5.1.6.2.8 Corrective Action

Failures, malfunctions, deficiencies, deviations, defective components, uncontrolled combustible material and nonconformance's which affect fire protection are controlled as discussed in the OQAM, Section 16.0.

9.5.1.6.2.9 Records

Records are maintained to show the applicable Fire Protection QA program criteria commitments are being satisfied for activities affecting the Fire Protection Program in accordance with the OQAM, Section 17.0.

9.5.1.6.2.10 Audits

Fire Protection will be audited on a triennial frequency utilizing an audit team meeting the qualification requirements of the Operating Quality Assurance Manual (OQAM), Section 18.3 and 18.4. The audit scope will address plant areas with fire protection with emphasis upon the following attributes:

- Installed Fire Detection and Extinguishing System Equipment
- Fire Barriers
- Fire Loading
- Fire Protection System Preventative Maintenance
- Correction of identified deficiencies of Fire Protection System Equipment
- Control of Transient Combustibles in Safety Related Areas
- Training on Fire Prevention and Fire Fighting Procedures
- Response to Fire Emergencies
- Corrective Actions for Previously Identified Fire Protection Problems
- Other Fire Protection Controls and Requirements
- Fire Protection Supplemental Quality Assurance Program Criteria (FSAR SP 9.5.1.6.2)
- Monitoring
    - Review systems with performance criteria. Do performance criteria still effectively monitor the functions of the system? Do the criteria still monitor the effectiveness of the fire protection and nuclear safety capability assessment systems?
    - Have the supporting analyses been revised such that the performance criteria are no longer applicable or new fire protection and nuclear safety capability assessment SSCs, programmatic elements and/or functions need to be in scope?
    - Based on the assessment period, are there any trends in monitored elements that should be addressed that are not being addressed?

The audit of Fire Protection Equipment, Programmatic Controls, and Implementing Procedures will utilize a qualified offsite Fire Protection Engineer meeting or exceeding the 'member' requirements of the Society of Fire Protection Engineers.

9.5.2 COMMUNICATION SYSTEMS

The communication systems include internal (in-plant) and external communications designed to provide convenient and effective communications among various plant locations, and between the plant and locations external to the plant.

9.5.2.1 Design Bases

9.5.2.1.1 Safety Design Bases

There is no safety design basis for the communication systems.

9.5.2.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - Intraplant voice communication is provided by a public address (PA) and telephone system.

POWER GENERATION DESIGN BASIS TWO - A maintenance jack system, utilizing plug-in telephone type handsets and handsets with 5-channel jack stations, is provided to supplement the public address system.

POWER GENERATION DESIGN BASIS THREE - An evacuation alarm system is provided to serve the entire plant.

POWER GENERATION DESIGN BASIS FOUR - A telephone system is provided for plant-to-offsite communication on a continuous basis.

POWER GENERATION DESIGN BASIS FIVE - Telephone communication is provided between the control room and various plant locations.

POWER GENERATION DESIGN BASIS SIX - A plant 800 MHz Radio is provided for plant radio-to-radio, plant radio-to-phone, and offsite plant-to-plant communications.

POWER GENERATION DESIGN BASIS SEVEN - A plant pager communication is provided for the Medical Emergency Response Team and the Fire Brigade.

POWER GENERATION DESIGN BASIS EIGHT - A plant fiber optic communication System is provided for voice, video, data communication and telemetering.

POWER GENERATION DESIGN BASIS NINE - Plant communications are provided for security system communications.

POWER GENERATION DESIGN BASIS TEN - A control-room-to-offsite communication system is also provided for emergency purposes.

POWER GENERATION DESIGN BASIS ELEVEN - A plant microwave communication system is provided for voice, video, data communication and telemetering.

9.5.2.2 System Description

The plant communication systems are illustrated schematically in Figures 9.5.2-1, 9.5.2-2, 9.5.2-3, and 9.5.2-4.

9.5.2.2.1 Intraplant Communications

Communications within the plant are provided as follows:

a. For operating purposes, a public address system is provided, consisting of handset stations and loudspeaker assemblies, each having its own plug-in amplifier.

   The system provides six separate independent communication channels--one general page, one Control Room page and four party lines. Communication between parties within the plant can be easily and quickly established by using the general page channel. Communication between parties in the plant and the Control Room can be easily and quickly established using the Control Room page channel. The party line channel is normally used after the page call is completed. As many as four party lines may communicate simultaneously. The portion of the PA system connecting the fuel transfer area in the containment, the spent fuel area and new fuel handling area in the fuel building, and the control room can be isolated from the remainder of the PA system from the control room. This permits extended use of the fuel handling communications system without disruption to the remainder of the system.

   The PA system is supplied power from two separate 208/120-V instrument busses and an uninterruptible power supply (UPS) connected to the non-vital 125 Vdc system through a transfer switch. In case of failure of the normal power source and the UPS, an automatic transfer is made to the alternate source. Each instrument bus is fed through an isolation transformer and can be supplied power by one of the emergency diesel generators.

   Each PA amplifier unit is equipped with an adjustable volume control which may be turned up in high noise areas.

   Handset stations are designed with a noise-cancelling mouthpiece for use in high noise areas.

A wall-mounted handset station is provided for communication between the auxiliary control panel and other areas of the plant.

b. For communications between the control room and equipment being maintained, calibrated, or tested, a five-channel maintenance jack system consisting of a permanently interconnected series of jack stations is provided. The system provides two-way communication between multiple stations on a preselected channel by means of plug-in headsets. Power is provided through the same sources as the PA system described above.

c. An audible alarm system is provided by means of a multitone generator whose output is broadcast throughout the plant via the public address system. A volume control bypass relay provides maximum sound. The audible alarm system is supplemented by visual alarms in high noise areas. Manual activation of the system is from the main control room. The alarms are as follow:

1. Plant Fire Alarm - A siren used only in the event of fire emergencies.

2. Plant Emergency Alarm - A yelping sound used to alert site personnel of unusual or abnormal conditions.

3. Containment Evacuation Alarm - A pulsing tone alerting site personnel that an abnormal condition exists inside the containment building and that it should be evacuated.

d. The telephone system consists of digital automatic switchboard (DPBX) equipment and telephone stations. The DPBX is provided with redundant processors for reliability. The telephone stations are located throughout the power block, in the main control room, in the various buildings around the site, in the security building, and in the service building where the admininstrative offices are located. The Control Room has cordless telephones that have been evaluated for no EMI/RFI concerns.

To enhance the existing wired telephone system and provide an alternate means of communication to the Plant Gai-tronics PA system, a site-wide cell phone system is provided. The cell phone system has two base stations that connect to the off-site commercial cell phone system. One base station is in the Service Building microwave room and the other is in the 2061’ elevation Plant Radio Room of the Communications Corridor. Each base station provides service to a fiber connected Distributed Antenna System (DAS) to provide coverage throughout the Main Power Block and Site-related buildings. The Main Power Block cell phone system uses the Plant Radio System DAS through a combiner device. The proper exclusion zones/distances will be maintained for cell phones to prevent any EMI/RFI concerns.

The power to the telephone (DPBX) equipment is provided by a 48 VDC battery system with redundant battery chargers supplied from 120 VAC obtained from two circuits on the Non-Class 1E power system in the Service Building. The one circuit which serves one battery charger is backed up by the security diesel generator.

For emergency use, unlisted telephone numbers are provided for direct access to the outside local public telephone system. At least one unlisted number is on the telephone in each of the following locations:

1. The Shift Supervisor's Office;

2. Security.

9.5.2.2.2 Plant 800 MHz Radio System

UE maintains a six channel 800 MHZ trunked radio system for overall plant site area coverage reaching out as far as the intake structure. This two-way radio system provides communications for operating purposes with plant radio-equipped vehicles and plant hand-held portable radios. These systems are for use during normal operation or during a plant emergency. This radio system is available on the control room radio consoles, on the security radio consoles, on the EOF radio console, and the the TSC radio console.

9.5.2.2.3 Plant Pager System

The plant pager system utilizes a local area paging system. The local area paging system has towers with transmitters within line-of-sight to the plant. Amplifiers and antennas on plant buildings provide the paging signals throughout these buildings.

9.5.2.2.4 Fiber Optic Communication

a. Communication Transport System (Fiber Optic Based)

The Communication Transport System consists of fiber-optic cables and fiber-optic terminal equipment providing high-speed digital service to between various site buildings as well as offsite company facilities. These high-speed digital services may be converted to a traditional voice freqency circuit through telecommunication multiplexers.

The Communication Transport System and telecommunication multiplexers are engineered for normal system voice communiations, telemetering, computer data and protective relaying. The communications handled by this system include:

1. The telephone trunks from the UE St. Louis office swtichbard to the DPBX equipment.

2. Three off premise telephone stations (OPS) from the UE St. Louis office switchboard, one for Nuclear Operations and another for Nuclear Information Servies.

3. Two direct telephone circuits from the Load Dispatch Office (LDO) to the unit's Control Room.

4. Connection to the UE 800 MHz radio system.

The Callaway Plant Communication Transport System handles the supervisory control to the Intake Structure, the telephone circuits and the Public Address System circuits between the power block and the Intake Structure.

The 24 VDC battery for all the plant communication transport equipment is charged by redundant battery chargers supplied from Non-Class 1E AC buses in the Service Building. A diesel generator backs up one AC bus, which serves one battery charger.

b. The fiber optic system provides a physical medium for various purposes including the inter-site and intra-site exchange between buildings of voice, video, data communications and telemetering.

9.5.2.2.5 Microwave Communications System

The microwave communications system provides redundancy for various purposes including the inter-site and intra-site exchange between buildings of voice, video, data communications.

9.5.2.2.6 Emergency Communications

A description of additional emergency communications is given in Section 7.2 in the Radiological Emergency Response Plan (RERP).

9.5.2.2.7 Security System Communications

Refer to Section 13.6 of the Site Addendum for information on the security system communications.

9.5.2.3 System Evaluation

Diverse systems are provided to assure a means of communication. For additional reliability, the PA system is supplied from either of two 208/120-V instrumentation

busses, which can be supplied by redundant diesel generators. Power to each of the instrumentation busses is fed through isolation transformers connected to a Class 1E motor control center. In the event the primary source power is unavailable, the PA system can also be supplied from an uninterruptible power supply powered by the non-vital 125 Vdc system.

The PA and maintenance jack systems are provided with power from the same sources, but are completely independent.

Those plant areas which must be manned for hot shutdown have been evaluated to ensure that the expected noise levels will not make the provided communication systems ineffective. These areas are listed in Table 9.5.3-1.

Of all the areas listed in Table 9.5.3-1, the only area where high noise levels are expected is the diesel generator room. However, all PA amplifiers may be turned up by means of the volume control.

The telephone, public address, and maintenance jack systems each have their own dedicated conduit systems, except for routing of communications cables on the refueling machine. It is not practical to provide a dedicated conduit system for the communications cables over the festoon, cat-track and conduits on the refueling machine. To the extent practicable, the dedicated conduits are embedded to minimize the system exposure to hazards.

A malfunction of a given system component will disable that particular component; hence, communications would have to be resumed using one of the remaining systems from that station. An accident, such as a fire, that disables a PA system loop would disable that particular communications loop, and, thus, communications would have to revert to one of the remaining systems for that entire loop. The maintenance jack system, if disabled by fire, would require repair before it could be restored to service. Should the PA and maintenance jack systems become inoperable, two-way radios and telephones are available. There are no safety functions associated with the communication systems.

9.5.2.4 Tests and Inspections

Systems of the types described above are conventional and have a history of successful operation at existing plants.

The performance and integrity of the communications systems described above are demonstrated by their frequent operation.

Where applicable, the radio equipment will be checked and calibrated in accordance with the latest rules and regulations of the Federal Communication Commission governing this type of operation.

9.5.3 LIGHTING SYSTEM

The plant lighting systems include normal, standby, and emergency lighting designed to provide adequate lighting during normal operation, accident conditions, and a loss of offsite power.

9.5.3.1 Design Bases

9.5.3.1.1 Safety Design Bases

The lighting system has no safety design bases.

9.5.3.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - Adequate lighting systems are provided in areas used during shutdown or emergency, including the appropriate access or exit routes.

POWER GENERATION DESIGN BASIS TWO - Lighting intensities are designed for those levels recommended by the Illuminating Engineering Society.

POWER GENERATION DESIGN BASIS THREE - Mercury-vapor fixtures are not used inside the containment or directly above the spent fuel pool.

POWER GENERATION DESIGN BASIS FOUR - The main control room is given special attention to reduce glare and shadows at the control boards.

9.5.3.2 System Description

The plant lighting distribution systems are illustrated schematically in Figure 9.5.3-1.

9.5.3.2.1 Normal Lighting System

The normal lighting system consists of a complete distribution network of cables, raceways, transformers, lighting panels, fixtures, receptacles, and switches.

This system is fed from the non-Class 1E auxiliary power system and is designed to provide adequate illumination levels for normal plant operating and service conditions. A selected number of normal lighting fixtures are chosen to be used in the standby lighting system.

9.5.3.2.2 Standby Lighting System

The standby lighting system consists of selected fixtures of the normal lighting system in the UHS cooling tower, ESW pumphouse, auxiliary, control, reactor, and turbine buildings. These fixtures are supplied from the emergency diesel generators during the

loss of offsite power and are isolated from the Class 1E power source on the occurrence of an SI signal. These circuits are treated as non-Class 1E, nonassociated.

9.5.3.2.3 Emergency Lighting Systems

The emergency lighting system consists of individual sealedbeam, self-contained, battery units to provide silhouette lighting, that is, to provide shadows and to highlight obstructions to personnel for access and egress. Emergency lighting battery units are located throughout the plant for access and egress to and from these areas. The locations of emergency lighting fixtures have been selected to provide for access and egress to/from the auxiliary, control, fuel, diesel generator, reactor, and radwaste buildings; the communication corridor; and the ESW pump house. Lighting to and from the radwaste building and the ESW pump house is provided by the site. The emergency lighting provided ensures egress from these areas in the event of a loss of off-site power, or a design basis event, should the normal lighting and standby lighting (powered by the emergency diesels) be unavailable.

As described in Appendix 5.4A, the SNUPPS design ensures that there are no preplanned manual operations outside of the control room for maintenance of hot shutdown following a design basis event, a severe natural phenomenon, or a loss of offsite power. The SNUPPS design also includes provisions to achieve and maintain hot and cold shutdown using safety-related equipment.

For cold shutdown, operator actions may be required in the electrical penetration rooms (1409 and 1410) to isolate the accumulator tanks and to open the RHR suction valves from the hot legs. These actions may be taken as late as 72 hours following an event. The safe shutdown scenario does not require access to the containment for hot or cold shutdown.

In areas required to be manned for safe shutdown, sufficient lighting will be directed at the control panels to enable operation of controls, including the main control board

In the area above the main control board and operator's console, the emergency lighting system consists of fixtures supplied from a Class 1E battery through a normally deenergized contactor. The contactor control circuit monitors the normal ac lighting feed and automatically energizes the fixtures from one Class 1E battery upon loss of ac power. The contactor, switch, wiring, raceways, and fixture mounting for this system are equivalent to Class 1E with regard to separation, color coding, and seismic supports.

One and one-half hour battery units are used in the turbine building and the Laundry Decontamination Facility. Each unit is connected to the normal lighting ac source for maintaining the charge and is automatically transferred to its internal batteries upon loss of ac power.

9.5.3.3 Failure Analysis

The emergency lighting system is designed to provide lighting at all times in areas used during shutdown or emergency. In the event of loss of offsite power, the emergency lighting will be maintained by batteries, as outlined in Section 9.5.3.2.3. The standby lighting system in these areas will be powered from the emergency diesel generators in the event of the loss of offsite power. Refer to Section 9.5.3.2.2.

9.5.3.4 Tests and Inspections

AC lighting circuits are normally energized and require no periodic testing. The dc emergency lighting is inspected and tested periodically to ensure the operability of the automatic switches and other components in the system.

9.5.4 EMERGENCY DIESEL ENGINE FUEL OIL STORAGE AND TRANSFER SYSTEM

The emergency diesel engine fuel oil storage and transfer system (EDEFSTS) provides onsite storage and transfer of fuel oil to the diesel engines.

9.5.4.1 Design Bases

9.5.4.1.1 Safety Design Bases

The EDEFSTS is safety related and is required to function following a loss of offsite power to achieve and maintain the plant in a safe shutdown condition.

SAFETY DESIGN BASIS ONE - The EDEFSTS is protected from the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, and external missiles (GDC-2).

SAFETY DESIGN BASIS TWO - The EDEFSTS remains functional after a SSE and performs its intended function following the postulated hazards of fire, internal missile, or pipe break.

SAFETY DESIGN BASIS THREE - Safety functions can be performed, assuming a single active component failure coincident with the loss of offsite power (GDC-44).

SAFETY DESIGN BASIS FOUR - The active components are capable of being tested during plant operation. Provisions are made to allow for inservice inspection of

components at appropriate times specified in the ASME Boiler and Pressure Vessel Code, Section XI (GDC-45 and 46).

SAFETY DESIGN BASIS FIVE - The EDEFSTS is designed and fabricated to codes consistent with the quality group classification assigned by Regulatory Guide 1.26 and the seismic category assigned by Regulatory Guide 1.29. The power supply and control functions are in accordance with Regulatory Guide 1.32.

SAFETY DESIGN BASIS SIX - Following a loss of offsite power, the system provides onsite storage and delivery of fuel oil for at least 7 days of operation of the diesel generators at their continuous rating.

SAFETY DESIGN BASIS SEVEN - Following a loss of offsite power, the EDEFSTS is designed to supply fuel oil at all times under the most severe environmental conditions probable at the plant site. The EDEFSTS complies with Regulatory Guide 1.137 to the extent discussed in Table 9.5.4-3.

9.5.4.1.2 Power Generation Design Basis

The EDEFSTS serves no power generation function.

9.5.4.2 <u>System Description</u>

9.5.4.2.1 General Description

The EDEFSTS is shown schematically in Figure 9.5.4-1. Each diesel engine has its own individual fuel oil storage and transfer system. The EDEFSTS for each diesel engine has an underground storage tank with a transfer pump, day tank, strainers and filters, piping, valves, instruments, and controls. The oil fill connection to the underground storage tank is located above grade and includes a strainer. A truck connection, normally isolated by a locked closed valve, is provided on the transfer pump discharge piping to empty the fuel oil storage tank, if necessary, using the transfer pump.

Two wye strainers are installed in parallel on the transfer pump discharge piping to the day tank with an isolation capability so that the flow can be diverted to either strainer without disrupting the system operation.

An interconnecting pipe with normally locked closed valves is installed between the two transfer systems to enable the supply of fuel oil from either storage tank to be transferred to either day tank. FSAR Figure 9.5.4-1 indicates that the cross-connection piping between the two fuel oil tanks is Seismic Category I. This will ensure the capability to supply fuel oil to either engine from either tank.

The day tank supplies fuel oil to the diesel engine by gravity. Duplex basket strainers and duplex oil filters are installed in series on the fuel oil lines from the day tank to the engine.

The excess fuel from the engine is returned to the day tank. Leakage from the injection nozzles is drained by gravity to the fuel oil storage tank.

Precautions have been taken in the design of the fuel oil system in locating the fuel oil day tank and connecting fuel oil piping in the diesel generator room with regard to possible exposure to ignition sources such as open flames and hot surfaces. The fuel oil day tank is located more than 20 feet horizontally from the diesel engine and well below the insulated diesel exhaust piping and, therefore, will not be exposed to any high temperature surfaces. There is no elevated fuel oil piping adjacent to the engine. The fuel oil piping between the engine and the day tank drops down from the tank and runs along the floor until it reaches the engine. The diesel engine itself sits on a 6-inch skid and, therefore, is elevated above the floor.

There are no open flames in the diesel generator room. Open flames in the diesel generator area as well as in other plant areas are controlled by plant administrative procedures.

9.5.4.2.2 Component Description

Codes and standards applicable to the EDEFSTS are listed in Tables 3.2-1 and 9.5.4-1. The EDEFSTS is designed and constructed in accordance with quality group C and Seismic Category I.

a. Emergency Fuel Oil Storage Tanks

   Two cylindrical emergency fuel oil storage tanks, one for each diesel engine, are provided. The tanks are horizontal and have elliptical heads.

   The tanks are buried underground near the diesel generator building. The capacity of each tank is based on the fuel consumption by one diesel engine for operation at continuous rating for 7 days. The tank is vented, via a flame arrester, to the atmosphere outside the diesel building at a location above all the tank connections.

   A concrete vault is provided on top of each tank to permit access to the manhole, the pump, the pump discharge piping and conduits, level transmitters, and sample line.

   The storage tanks have integral sumps. Each tank is sloped to the sump. Sample lines extend from the sumps to the vaults for periodic bottom sampling and water draw-off. The sample lines can be used to empty the storage tanks when the fuel oil level falls below the transfer pump suction.

   The storage tanks are buried below grade at a sufficient depth to prevent floating when the tanks are emptied. Fill lines are installed above the probable maximum flood level to prevent any entry of water into the tank.

The exterior surfaces of the tanks are coated with bitumastic and wrapped for additional protection. The interior surfaces of the tanks are coated with bitumastic. An impressed-current-type cathodic protection is provided for the tanks.

b. Emergency Fuel Oil Transfer Pumps

Two transfer pumps are provided, one for each diesel generator. The pumps are the horizontal centrifugal type and are submerged in their respective fuel oil storage tanks. Each pump motor is powered from the same Class 1E bus its associated diesel generator serves. The capacity of each transfer pump is approximately twice the consumption rate of the diesel engine at its continuous rating.

c. Emergency Fuel Oil Day Tanks

Two cylindrical day tanks are provided, one for each diesel engine. The day tanks are horizontal and have flanged and dished heads. Each day tank is installed in the room of the engine it serves, and the tank elevation ensures adequate net positive suction head on the diesel engine-driven fuel oil pump at all times. Each day tank has a capacity equal to approximately 1.30 hours of operation of the diesel engine at its continuous rating. The tanks are vented, via a flame arrester, to outside the diesel generator building. The overflow and drain connections on the day tank are piped to the emergency fuel oil storage tank. A sampling connection is provided to the bottom of the tank for periodic sampling of the fuel oil for quality and for drawing off any accumulated condensation and sediment.

The interiors of the day tanks are waterproofed with a coating of bitumastic.

Instrumentation is provided, as described in Section 9.5.4.5. The level settings ensure that there is at least a 1-hour supply of oil, plus a 10 percent margin in each day tank for the diesel engine (based on the fuel consumption rate at 100 percent of the engine continuous rating) at the level where the oil is automatically added to the day tanks by the transfer pumps in the storage tanks.

d. Piping and Valves

All piping in the EDEFSTS is carbon steel. The exterior surfaces of the underground piping are coated with coal tar and wrapped. Cathodic protection is provided for underground piping.

The fuel oil storage tank vent and fill lines are nonseismic above grade and are seismic Category I below grade (refer to FSAR Figure 9.5.4-1). The lines rise above grade within the diesel generator building and then

penetrate the building wall to the outside. The portion of these lines within the building is seismically restrained. Failure of these lines does not jeopardize operation of the diesel. If the fill line is unusable and the tanks have to be replenished, the tank manhole can be used as the fill and vent connection.

In addition to the transfer line, the storage tank and the day tank are also interconnected via the overflow and recirculation lines. Should the storage tank vent be totally restricted, venting can occur through the day tank.

Since failure of the nonseismic storage tank vent and fill lines will not prevent system operation, no tornado protection is provided.

The provisions in the design to prevent entrance of water into the storage tank during adverse environmental conditions, including maximum probable flood conditions, include a vent line with a flame arrestor, which is goosenecked downward and a fill connection which is capped and penetrates the building wall at approximately 3 feet above grade. The maximum probable flood level does not exceed grade and, therefore, the vent and fill connections are not subject to flood conditions. The bottom of the flame arrestor is approximately 15 feet above grade. As noted, the fill connection is capped and the vent goosenecked down and, therefore, neither will allow the entrance of water into the system during adverse environmental conditions.

9.5.4.2.3 System Operation

Each diesel engine has its own independent fuel oil pumping train from the fuel oil storage tank to the day tank, with suitable tie lines normally isolated between the two flow paths. Level transmitters installed on the day tanks initiate the signals to start the transfer pumps on low level and stop the pumps on a high level. If the diesel generators are running, the transfer pumps will run continuously.

A fire detection signal from the diesel building will stop the fuel oil transfer pump. However, automatic diesel actuation will override any fire detection signal to preclude any spurious trips from the fire protection system under accident conditions.

Fuel oil is supplied by gravity to the diesel engine-driven fuel oil pumps.

The storage tanks are replenished by delivery trucks through the oil fill connections located above grade. Accumulated sediment and moisture may be withdrawn prior to adding new fuel to minimize the possibility of degrading the overall quality of the new fuel.

Fuel oil may be added to the tank of an operating diesel, however this is not a preferred or conservative practice. Technical Specification fuel quantities ensure filling a tank of an operating diesel is unlikely.

In the unlikely event that one of the oil storage tanks must be replenished without interruption of the associated diesel generator the tank and fuel system design ensure that any sediment stirred up during replenishment does not reach the injection nozzles.

Contingency procedures provide for operating a diesel generator utilizing the cross connect piping.

9.5.4.3 Safety Evaluation

Safety evaluations are numbered to correspond to safety design bases in Section 9.5.4.1.

SAFETY EVALUATION ONE - With the exception of the fill and vent connections, the aboveground portions of the EDEFSTS are located inside the diesel generator building. This building is designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other natural phenomena. Sections 3.3, 3.4, 3.5, 3.7(B), and 3.8 provide the bases for the adequacy of the structural design of this building. The underground portions of the EDEFSTS have adequate earth coverage for missile protection. The access vaults for the storage tanks are missile protected. The missile covers and vaults form watertight barriers to prevent water entry into the tanks from ground water and flooding.

SAFETY EVALUATION TWO - The safety-related portions of the EDEFSTS are designed to remain functional after a safe shutdown earthquake. Sections 3.7(B).2 and 3.9(B) provide the design loading conditions that were considered. Sections 3.5, 3.6, and 9.5.1 provide the hazards analyses to assure that a safe shutdown, as outlined in Section 7.4, can be achieved and maintained.

SAFETY EVALUATION THREE - The design of the EDEFSTS provides complete redundancy; therefore no single failure will compromise the system's safety functions. All vital power can be supplied from either onsite or offsite power systems, as described in Chapter 8.0.

SAFETY EVALUATION FOUR - The EDEFSTS is initially tested with the program given in Chapter 14.0. Periodic inservice functional testing is done in accordance with Section 9.5.4.4.

Section 6.6 provides the ASME Boiler and Pressure Vessel Code, Section XI requirements that are appropriate for the EDEFSTS.

SAFETY EVALUATION FIVE - Section 3.2 delineates the quality group classification and seismic category applicable to the safety-related portion of this system. Table 9.5.4-1

shows that the components meet the design and fabrication codes given in Section 3.2. All the power supplies and control functions necessary for safe function of the EDEFSTS are Class 1E, as described in Chapters 7.0 and 8.0.

SAFETY EVALUATION SIX - The capacity of each emergency fuel oil storage tank is sufficient for 7 days of operation of one diesel generator at its continuous rating. Within this period, additional fuel can be delivered to the plant site by truck.

SAFETY EVALUATION SEVEN - Maintenance of the fuel oil temperature is achieved by enclosing the equipment in heated buildings for portions of the system above ground or by burial below the frostline of underground portions of the system.

9.5.4.4 Tests and Inspections

Preoperational testing is described in Chapter 14.0.

The EDEFSTS is tested periodically, along with the complete diesel generator system. This test will demonstrate the performance and structural and leaktight integrity of all the system components.

With the exception of underground portions of the system, all equipment and components are readily available for inspection and maintenance. Provisions are made to pressure test the underground portions of the system. The fuel oil transfer pumps can be tested independently of the diesel generator by draining the day tanks (manually to the storage tanks) to the levels that automatically start the pumps. The pump flowrate can be verified by monitoring the day tank level indicators. Level annunciators in the storage tanks can be used to verify the leaktightness of the tanks.

The fuel oil in the storage tank and day tanks will be periodically sampled to verify quality. Degenerated fuel oil can be pumped out of the storage tanks by truck connections provided on the discharge of each fuel oil transfer pump. Accumulated moisture and sediment may be removed periodically, via the sample line, to minimize degradation of the fuel oil.

9.5.4.5 Instrumentation Applications

The EDEFSTS instrumentation is designed to provide indication of system parameters and automatic operation of the transfer pumps. Instruments, controls, sensors, and alarms for the diesel fuel oil storage and transfer system are shown on Figures 9.5.4-1 and 9.5.6-1.

The emergency fuel oil storage tanks have level transmitters to alarm in the control room on low level (corresponding to 7-day capacity) and a low-low level to indicate low suction head for the transfer pumps. A local outdoor level indicator is also provided.

The day tanks have level transmitters to automatically start and stop the transfer pumps. In addition, control room annunciation of high level and low levels is provided to indicate system malfunction. The low level alarm is provided to allow sufficient time for the operator to accomplish minor repairs if required,before all fuel in the day tank is consumed. Day tank level indicators are provided in the local diesel engine control panels and in the main control room.

The strainers and filters installed in the system have pressure differential switches and pressure differential indicators. High differential pressure across the strainer in the transfer pump discharge is alarmed in the control room, whereas a high differential pressure across the strainers and filters on the diesel engine skid is annunciated on the local control panel. Low fuel oil pressure downstream of the diesel engine-driven pump is annunciated in the local control panel. A common alarm is provided in the control room for any local annunciator.

None of the above alarm conditions will result in harmful effects to the diesel engine, and none will result in the tripping of the diesel engine. Station operating procedures give the operators guidance for responding to these alarms.

Test connections are provided on the fuel oil transfer pump discharge lines to monitor the pressure or temperature, if desired.

Table 9.5.4-2 summarizes the EDEFSTS alarms and indicators of various system parameters.

9.5.5 EMERGENCY DIESEL ENGINE COOLING WATER SYSTEM

The emergency diesel engine cooling water system (EDECWS) provides cooling water to the emergency diesel engines. This is a closed cycle system, and serves as an intermediate system between the diesel engines and the essential service water system.

The diesels are totally redundant and do not share systems, nor are there any interconnections between the two engine cooling systems. Therefore, no failure of or between any of the engine cooling subsystems would result in any degradation of the other diesel engine.

9.5.5.1 Design Bases

9.5.5.1.1 Safety Design Bases

The EDECWS is safety related and is required to function following a DBA and to achieve and maintain the plant in a safe shutdown condition.

SAFETY DESIGN BASIS ONE - The EDECWS is protected from the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, and external missiles (GDC-2).

SAFETY DESIGN BASIS TWO - The EDECWS remains functional after a SSE and performs its intended function following the postulated hazards of fire, internal missiles, or pipe break (GDC-3 and 4).

SAFETY DESIGN BASIS THREE - Safety functions can be performed, assuming a single active component failure coincident with the loss of offsite power (GDC-44).

SAFETY DESIGN BASIS FOUR - The active components are capable of being tested during plant operation. Provisions are made to allow for inservice inspection of components (GDC-45 and 46).

SAFETY DESIGN BASIS FIVE - The EDECWS is designed and fabricated to codes consistent with the group classification assigned by Regulatory Guide 1.26 and the seismic category assigned by Regulatory Guide 1.29. The power supply and control functions are in accordance with Regulatory Guide 1.32.

SAFETY DESIGN BASIS SIX - The EDECWS is designed to remove heat from the diesel engines to permit their operation at continuous nameplate rating.

SAFETY DESIGN BASIS SEVEN - The EDECWS is designed to maintain the diesel engine in a hot standby condition to ensure quick starting of the diesel engine.

9.5.5.1.2 Power Generation Design Bases

The EDECWS has no power generation design bases.

9.5.5.2 System Description

9.5.5.2.1 General Description

The EDECWS is shown schematically in Figure 9.5.5-1. Each diesel engine has its own cooling water system. Each cooling water system consists of a jacket cooling water system and an intercooler cooling system.

The EDECWS rejects heat to the essential service water system.

Each jacket cooling water system consists of an engine-driven pump, a jacket water heat exchanger, an electric motor-driven keepwarm pump, an electric keepwarm heater, piping, valves, controls, and instrumentation. The engine-driven pump circulates water through the cylinder jackets, and the jacket water heat exchanger, where the extracted heat is transferred to the essential service water system. When on standby status, the electric motor-driven pump circulates water through the electric heater and the engine cylinder jackets to keep the engine warm.

Each intercooler cooling system consists of an engine-driven intercooler pump, intercooler heat exchanger, piping, valves, controls, and instrumentation. The

engine-driven intercooler pump circulates water through the intercooler heat exchanger and the engine-mounted intercoolers. Turbocharged air is cooled by the intercoolers prior to its entry into the combustion air manifold, and the extracted heat is transferred to the essential service water system at the intercooler heat exchanger.

An expansion tank is provided to accommodate any volumetric changes in the EDECWS due to thermal transients or leakage and to absorb pump pulsations. The expansion tank maintains adequate suction at the engine-driven pumps and provides a release point for undissolved gases in the system.

The jacket water and intercooler cooling systems have high point vents which are piped to the jacket water expansion tank. This ensures that the systems are filled with water at all times.

9.5.5.2.2 Component Description

Codes and standards applicable to the EDECWS are listed in Tables 3.2-1 and 9.5.5-1. The safety-related portions of the EDECWS are designed and constructed in accordance with quality group C and seismic Category I.

ENGINE-DRIVEN COOLING WATER PUMPS - The jacket cooling water pump and the intercooler pump are driven by the engine. The pumps are the horizontal centrifugal type. Adequate suction is provided by the jacket water expansion tank. A failure of either of these pumps constitutes an engine failure.

HEAT EXCHANGERS - The heat exchangers in the EDECWS are the horizontal shell and tube type. Essential service water is supplied to the tube side. The heat exchangers are arranged in series so that the essential service water first flows through the intercooler heat exchanger and then the jacket water heat exchanger.

EXPANSION TANK - One expansion tank is provided in the EDECWS to accommodate volumetric changes in the jacket cooling water and intercooler cooling water systems due to thermal transients or leakage. The expansion tank serves to absorb any pump pulsations. The tank is a horizontal cylindrical type and is located at a suitable elevation to provide adequate suction head to the engine-driven pumps.

The makeup to the expansion tank is from the demineralized water storage and transfer system which is nonseismic Category I. The makeup quantities are controlled automatically by level switches. The capacity of the expansion tank is based on providing sufficient reserve capacity for operation of the diesel at continuous rating for at least 7 days. Provisions are included for the addition of chemicals, as required.

JACKET COOLING WATER KEEPWARM PUMP AND HEATER - An electric motor-driven keepwarm pump is provided to circulate water to the cylinder liners through an electric heater to keep the engine warm on standby. The pump and heater

combination on each diesel skid is powered from the same Class 1E bus served by their associated diesel generator.

PIPING AND VALVES - All piping in the EDECWS is carbon steel. The inlets to the heat exchangers are controlled by self-contained thermostatic valves. Section 9.2.1 describes the piping and valves associated with the essential service water system. Due to the manufacturer's service and design experience, the flex connections used within the EDECWS are of the nonmetallic type, are designed and constructed to manufacturer's standards, and have proven reliable for the intended service.

9.5.5.2.3 System Operation

GENERAL - The jacket cooling water system and the intercooler cooling water system are closed-cycle systems. High points in these systems are vented to the expansion tank. This assures that all spaces are filled with water when a water inventory is maintained in the expansion tank. The EDECWS uses demineralized water with a suitable corrosion inhibitor. The demineralized water chemistry conforms to the diesel engine manufacturer's recommendations.

When the engine is on standby, the jacket water keepwarm pump circulates water through the electric heater and the cylinder jacket. This keeps the engine warm to facilitate starting. The heater is controlled by a temperature switch. A failure of the keepwarm system will lower the jacket cooling water temperature. As described in Section 8.3, low jacket cooling water temperature will be alarmed locally and annunciated in the control room as a common trouble alarm.

During diesel engine operation, the keepwarm system is automatically shut off. The engine-driven jacket cooling water pump and the intercooler cooling water pump circulate cooling water. The heat extracted by the cooling water is transferred to the essential service water system at the jacket water and intercooler heat exchangers. The cooling water to each heat exchanger is modulated by a self-contained thermostatic valve, so that the temperature differentials across the engine in the jacket cooling water and the intercooler cooling systems will remain at the design minimum. The thermostatic valves bypass the heat exchangers when the engine is started so that the cooling water is rapidly brought to normal operating temperatures. The thermostatic valves are designed to permit the full volume of cooling water to flow through the engine. The expansion tank makes up for any volumetric changes due to thermal transients and minor leakage.

During normal plant operation, the service water system through the essential service water system piping provides a heat sink to the EDECWS. When the diesel is started during an emergency on a safety injection signal, the essential service water system absorbs the heat from the EDECWS. However, the essential service water pumps do not activate immediately because they are connected to power from the diesel generators. The normal period of diesel engine operation prior to the start of the essential service water flow is less than a minute. This includes the diesel generator start and

acceleration to its rated speed, energizing the sequencer for starting the essential service water pump motor, and starting and accelerating the essential service water pump motor to rated conditions. The diesel engines are designed to operate at a continuous nameplate rating without a cooling water supply for 3 minutes.

Loss of water from the EDECWS is detected by monitoring both the operation of the D-G room sump pump and the number of times makeup water is introduced into the system by monitoring the operation of the makeup water solenoid valve.

There are no mechanical limitations within the EDECWS that would restrict the operation of the diesel generator when less than full electrical power generation is required.

9.5.5.3 Safety Evaluation

Safety evaluations are numbered to correspond to the safety design bases.

SAFETY EVALUATION ONE - The EDECWS is located in the diesel generators building. This building is designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other appropriate natural phenomena. Sections 3.3, 3.4, 3.5, 3.7(B), and 3.8 provide the bases for the adequacy of the structural design of this building.

SAFETY EVALUATION TWO - The safety-related portions of the EDECWS are designed to remain functional after a safe shutdown earthquake. Sections 3.7(B).2 and 3.9(B) provide the design loading conditions that were considered. Sections 3.5, 3.6, and 9.5.1 provide the hazards analyses to assure that a safe shutdown, as outlined in Section 7.4, can be achieved and maintained.

SAFETY EVALUATION THREE - The design of the emergency diesel generators provides for complete redundancy; therefore no single failure of the EDECWS portion will compromise the diesel generators safety functions. All vital power can be supplied from either onsite or offsite power systems, as described in Chapter 8.0.

SAFETY EVALUATION FOUR - The EDECWS is initially tested with the program given in Chapter 14.0. Periodic inservice functional testing is carried out in accordance with Section 9.5.5.4.

SAFETY EVALUATION FIVE - Section 3.2 delineates the quality group classification and seismic category applicable to the safety-related portion of this system and supporting system. Table 9.5.5-1 shows that the components meet the design and fabrication codes given in Section 3.2 All the power supplies and control function necessary for the safe function of the EDECWS are Class 1E, as described in Chapters 7.0 and 8.0.

SAFETY EVALUATION SIX - The EDECWS components are sized to remove heat from the engine when operating at continuous nameplate rating and transfer this heat to the essential service water system.

SAFETY EVALUATION SEVEN - The EDECWS has a jacket water keepwarm system designed to keep the engine in a hot standby. This allows the quick start and loadings required for emergencies.

9.5.5.4 Tests and Inspections

Preoperational testing is described in Chapter 14.0.

The EDECWS is tested periodically, along with the complete diesel generator system. This test will demonstrate the performance, structural, and leaktight integrity of all the system components.

The safety-related portions of the EDECWS are designed and arranged (to the extent practical) to permit preservice inspection.

9.5.5.5 Instrumentation Applications

The EDECWS instrumentation is designed to permit automatic operation and remote control of the system and to provide continuous indication of system parameters. Refer to Section 8.3 for details of instrumentation. The local control panel has indicators for coolant pressure and coolant inlet and outlet temperatures. The frequency of makeup to the expansion tank is monitored by the data logger printout of the opening of the makeup water valve.

All applicable instruments, controls, sensors, and alarms for the diesel cooling water system are shown on FSAR Figure 9.5.5-1, Sheets 1 and 2.

Those temperatures and pressures which are alarmed in the diesel generator room but result only in the general control room "diesel trouble" alarm are high jacket water temperature from the engine, low jacket water temperature from the engine, low jacket water pump discharge pressure, low jacket water expansion tank level, high intercooler water temperature from the engine, low intercooler water temperature from the engine, and low intercooler pump discharge pressure. An operator would go to the alarm panel in the diesel generator room to determine the specific alarm.

There are no cooling water system alarms which alarm directly in the control room.

Local indication in the diesel generator room is provided for jacket water temperature to and from the engine, intercooler water temperature to and from the engine, water temperature from the generator outboard bearing, jacket water pump discharge pressure, and intercooler pump discharge pressure.

None of the above malfunctions which alarm in the control room will result in harmful effects to the diesel or shutdown, except for the high jacket water temperature from the engine. High jacket water temperature is sensed by four separately mounted

temperature switches, each at an increasing temperature set point. Operation of any one switch will sound an alarm, and operation of any two will result in engine shutdown.

Station operating procedures give the operators guidance for responding to these alarms.

9.5.6 EMERGENCY DIESEL ENGINE STARTING SYSTEM

The emergency diesel engine starting system (EDESS) provides a reliable method for starting the emergency diesel engines for all modes of operation.

The EDESS is divided into two parts -- a safety-related portion which is that portion downstream of and including the air start tank check valve and the remainder of the system which is nonsafety related.

9.5.6.1 Design Bases

9.5.6.1.1 Safety Design Bases

The safety-related portion of the EDESS is required to function following a DBA and to achieve and maintain the plant in a safe shutdown condition.

SAFETY DESIGN BASIS ONE - The EDESS is protected from the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, and external missiles (GDC-2).

SAFETY DESIGN BASIS TWO - The safety-related portion of the EDESS remains functional after a SSE and performs its intended function following the postulated hazards of fire, internal missiles, or pipe break.

SAFETY DESIGN BASIS THREE - Safety functions can be performed, assuming a single active component failure coincident with the loss of offsite power (GDC-44).

SAFETY DESIGN BASIS FOUR - The active components are capable of being tested during plant operation. Provisions are made to allow for inservice inspection of components (GDC-45 and 46).

SAFETY DESIGN BASIS FIVE - The safety-related portion of EDESS is designed and fabricated to codes consistent with the quality group classification assigned by Regulatory Guide 1.26 and the seismic category assigned by Regulatory Guide 1.29. The power supply and control functions are in accordance with Regulatory Guide 1.32.

SAFETY DESIGN BASIS SIX - The capability to isolate components, systems, or piping is provided, when required, so that the system's safety function will not be compromised. This includes isolation of components to deal with leakage or malfunctions and to isolate nonsafety-related portions of the system.

SAFETY DESIGN BASIS SEVEN - The safety-related portion of the EDESS is capable of storing sufficient air to allow for at least five consecutive crank cycles of approximately 3 seconds or 2 to 3 revolutions of the diesel engine without external support or assistance.

9.5.6.1.2 Power Generation Design Basis

The EDESS serves no power generation function.

9.5.6.2 System Description

9.5.6.2.1 General Description

The EDESS is shown schematically in Figure 9.5.6-1. Each diesel engine has its own starting system. The starting system for each diesel engine has two redundant, independent starting air trains, one for each bank of cylinders. Each starting air train consists of a compressor, dryer, starting air tank, filters, strainers, piping, valves, controls, and instruments. Each bank of engine cylinders has its own engine-driven air start distributor with a pilot air connection to each cylinder for operation of the cylinder air start valves. The engine will start on either or both banks of cylinders.

Starting air pressure is also used to operate the governor servorack booster which opens the fuel injection pump racks to ensure adequate fuel at startup.

For emergency shutdown, starting air pressure is used to operate a fuel rack shutdown cylinder to close the fuel racks.

The pressure transmitters associated with the pressure indicators on the local control panel are supplied with air from the starting air system.

9.5.6.2.2 Component Description

Codes and standards applicable to the EDESS are listed in Tables 3.2-1 and 9.5.6-1. The safety-related portion of the EDESS is designed and constructed in accordance with quality group C and seismic Category I.

COMPRESSORS - Each train of the diesel starting system has an electric motor-driven compressor. The compressor is a 3-stage air-cooled design with sufficient capacity to charge its associated air tank from minimum to maximum starting air pressure in less than 30 minutes. The compressor start/stop functions are automatically controlled by a pressure switch monitoring the starting air tank pressure. The compressor is nonsafety related, and the compressor motor is powered from a non-IE source.

Each compressor has an aftercooler to cool the compressed air. The aftercooler is nonsafety related and air cooled.

DRYERS - A desiccant air dryer is provided in each starting air train. The dryer is the automatic regeneration type and includes a prefilter and afterfilter. The dryer provides moisture-free air with a dew point temperature (at rated pressure) of minus 40°F. The dryer package is nonsafety related.

STARTING AIR TANKS - Compressed air is stored in the starting air tanks. Two starting air tanks are provided for each emergency diesel engine - one for each redundant starting air train. Each tank has sufficient capacity for five cranking cycles without recharging. The air tanks are equipped with safety valves and normally closed drains to blow down any accumulated moisture and sediments periodically. The starting air tank is safety related.

STRAINERS AND FILTERS - Each compressor inlet is fitted with a filter. A prefilter and afterfilter are installed in each dryer package. This assures that the dryer efficiency is maintained and that moisture-free clean air is supplied to the starting air tanks. A wye strainer with a 740-micron particle retention capability is provided downstream of each starting air tank. In addition, a wye strainer with a 149-micron particle retention capability is provided upstream of each air start solenoid valve in each starting air train. The strainers minimize the possibility of a malfunction of the components in the starting air system by particle entrapment.

PIPING AND VALVES - Carbon steel piping and valves are installed in the EDESS. The dryers provide moisture-free air. Manual drains are provided in the starting air tanks to blow down periodically any accumulated moisture. Therefore, rust formation in the carbon steel piping and valves is minimized. The strainers provide an additional safeguard against carryover of any rust particles to the starting air system components.

9.5.6.2.3 System Operation

Upon initiation of the diesel engine start sequence, the air start solenoid valves in the redundant starting air trains open to release sufficient air from the starting air tanks to the engine-mounted air start valves and the engine-driven air start distributors located on both banks of the engine cylinders. The air pressure operates the governor servorack booster to open the fuel racks to ensure adequate fuel during starting. The engine can be started from either or both banks of cylinders. The engine is maintained in a hot standby condition to facilitate quick start. The engine start and acceleration to synchronous speed at rated voltage and frequency is accomplished within 12 seconds. An engine start failure is annunciated in the control room (see Section 8.3).

The starting air tanks are automatically charged by the compressors. Pressure switches are installed in each starting air train, at the starting air tanks. These switches start and stop both compressors to maintain the required pressure in the tanks. An interconnecting pipe with a normally open valve is provided between the two starting air trains, upstream of the starting air tanks, so that either of the two compressors can charge both starting air tanks. Low starting air pressure is annunciated in the local panel

and in the control room (see Section 8.3). Safety relief valves are installed on each tank and compressor for overpressurization protection.

A barring gear interlock is provided in each starting air train to prevent the starting of the diesel engine when the barring gear is engaged. Engagement of the barring gear is annunciated in the local panel and in the control room.

Adequate isolation capabilities are provided in the EDESS to isolate the nonsafety-related portions of the system from the safety-related portion. The inlet piping to the starting air tanks has nonreturn valves and manual valves to isolate the tanks from the compressor circuit. Excess flow valves are installed in the air supply line to the various pressure transmitters on the engine skid.

Measures have been taken in the design of the standby diesel generator air starting system to preclude the feeding of the air start valve or filter with moisture and contaminants such as oil carryover and rust. Dryness of the air is ensured by use of a dessicant-type air dryer on each compressor. The air dryers are of the automatic recharging type, using purge flow to effect recharge of the dessicant. They are designed to provide air dried to a dew point of -40°F at the design flow rate of 31 scfm, which is well below the lowest design room temperature of 60°F. Air temperature entering the dryers is regulated by coolers mounted on the compressors. Oil carryover from the compressor is controlled by use of a prefilter upstream of the dryer, and dessicant carryover into the air system is prevented by pulsation dampers upstream and after-filters downstream of the dryers.

9.5.6.3 Safety Evaluation

Safety evaluations are numbered to correspond to the safety design bases.

SAFETY EVALUATION ONE - The safety-related portion of the EDESS is located in the diesel generators building. This building is designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other appropriate natural phenomena. Sections 3.3, 3.4, 3.5, 3.7(B), and 3.8 provide the bases for the adequacy of the structural design of these buildings.

SAFETY EVALUATION TWO - The safety-related portion of the EDESS is designed to remain functional after a safe shutdown earthquake. Sections 3.7(B).2 and 3.9(B) provide the design loading conditions that were considered. Sections 3.5, 3.6, and 9.5.1 provide the hazards analyses to assure that a safe shutdown, as outlined in Section 7.4, can be achieved and maintained.

SAFETY EVALUATION THREE - The design of the emergency diesel generators provides for complete redundancy; therefore single failure of the EDESS portion will not compromise the diesel generators safety function. All vital power can be supplied from either onsite or offsite power systems, as described in Chapter 8.0.

SAFETY EVALUATION FOUR - The EDESS is initially tested with the program given in Chapter 14.0. Periodic inservice functional testing is carried out in accordance with Section 9.5.6.4.

SAFETY EVALUATION FIVE - Section 3.2 delineates the quality group classification and seismic category applicable to the safety-related portion of this system and supporting systems. Table 9.5.6-1 shows that the components meet the design and fabrication codes given in Section 8.2. All the power supplies and control functions necessary for safe function of the EDESS are Class 1E, as described in Chapters 7.0 and 8.0.

SAFETY EVALUATION SIX - Section 9.5.6.2 describes provisions made to identify and isolate leakage or malfunction and to assure isolation of the nonsafety-related portions of the system.

SAFETY EVALUATION SEVEN - The redundant starting air trains in the engine starting system have independent starting air tanks. Each tank has a sufficient capacity to provide at least five diesel engine crank cycles without external support or assistance. The duration of each crank cycle is 3 seconds or 2 to 3 engine revolutions.

9.5.6.4 Tests and Inspections

Preoperational testing is described in Chapter 14.0.

The EDESS is tested periodically, along with the complete diesel generator system. This test will demonstrate the performance, structural, and leaktight integrity of all the system components. When the engine is on standby, the starting air system is normally pressurized up to the air start solenoid valves. Instrumentation is provided to indicate and alarm loss of air pressure. This provides an additional means of verification of the structural and leaktight integrity of the system when the engine is on standby.

The safety-related portions of the EDESS are designed and located (to the extent practicable) to permit preservice inspections.

9.5.6.5 Instrumentation Applications

The EDESS instrumentation is designed to facilitate automatic operation of the system and to provide continuous indication of system parameters. Refer to Section 8.3 for details of instrumentation. Local pressure indicators are provided on the starting air tanks. Pressure indicators are also installed in the local control panel for each starting air train.

All applicable instruments, controls, sensors, and alarms for the diesel starting air system are shown on FSAR Figure 9.5.6-1, Sheets 1 and 2.

The only system function which is alarmed in the diesel generator room is low air system pressure. This alarm also generates a general control room "diesel trouble" alarm. This malfunction will not result in any harmful effects to the diesel engine.

Local indication is provided for each starting air tank pressure and each starting air system pressure.

9.5.7 EMERGENCY DIESEL ENGINE LUBRICATION SYSTEM

The emergency diesel engine lubrication system (EDELS) provides essential lubrication and cooling for the components of the emergency diesel engine.

9.5.7.1 <u>Design Bases</u>

9.5.7.1.1 Safety Design Bases

The EDELS, excluding operation of the keepwarm components, is safety related and is required to function following a DBA and to achieve and maintain the plant in a safe shutdown condition.

SAFETY DESIGN BASIS ONE - The EDELS is protected from the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, and external missiles (GDC-2).

SAFETY DESIGN BASIS TWO - The EDELS remains functional after a SSE and performs its intended function following the postulated hazards of fire, internal missiles, or pipe break (GDC-3 & 4).

SAFETY DESIGN BASIS THREE - Safety functions can be performed, assuming a single active component failure coincident with the loss of offsite power (GDC-44).

SAFETY DESIGN BASIS FOUR - The active components are capable of being tested during plant operation. Provisions are made to allow for the inservice inspection of components (GDC-45 & 46).

SAFETY DESIGN BASIS FIVE - To the extent practicable, the EDELS is designed and fabricated to codes consistent with the quality group classification assigned by Regulatory Guide 1.26 and the seismic category assigned by Regulatory Guide 1.29. The power supply and control functions are in accordance with Regulatory Guide 1.32.

SAFETY DESIGN BASIS SIX - The capability to isolate components or piping is provided to deal with leakage or malfunctions (GDC-44).

SAFETY DESIGN BASIS SEVEN - The EDELS is designed to provide adequate lubrication and cooling for the various moving parts of the engine to permit it to be

operated at continuous nameplate rating for at least 7 days without replenishing the system.

SAFETY DESIGN BASIS EIGHT - The EDELS is designed to maintain the lubricating oil in a warm condition when the engine is on standby to facilitate quick starting, when required.

9.5.7.1.2 Power Generation Design Basis

The EDELS has no power generation design basis.

9.5.7.2 System Description

9.5.7.2.1 General Description

The EDELS is shown schematically in Figure 9.5.7-1. Each diesel engine is furnished with an independent lubrication system. The EDELS consists of two separate systems - the main oil system and the rocker oil system.

The main oil system supplies lubricating oil to the main bearings, pistons, camshaft bearings, cam followers, fuel injection pumps, camshaft, and accessory drive gears. The system consists of an engine-driven main oil pump, oil cooler, electric motor-driven prelube/keepwarm pump, keepwarm electric heater, auxiliary lubricating oil makeup tank, bypass filter, duplex full-flow strainer, piping, valves, controls, and instrumentation.

During engine operation, the engine-driven pump draws oil from the engine sump and delivers it through the oil cooler and strainer to the main engine oil header. The header supplies oil under pressure to lubricate and cool various components. After lubrication, the oil flows back to the sump through a return header.

On an engine standby status, the electric prelube/keepwarm pump draws oil from the engine sump and delivers it through an electric heater, filter, and strainer to the main engine lubricating oil header. The keepwarm system thus serves the following functions:

a. Maintains the oil in the sump in a warm condition to ensure a quick start.

b. Prelubricates the essential engine components to minimize the possibility of oil starvation.

c. Maintains oil purity by continuous filtration and straining.

The prelube/keepwarm system operates when the engine is running in order to provide a path for the bypass filtration of the oil in the sump.

To protect the crankcase oil from contamination by cooling water and fuel leaks at the cylinder head upper deck level, the valve rockers are lubricated and drained by a

separate rocker lubricating oil system. The system consists of an engine-driven pump, filter, reservoir, electric motor-driven prelube pump, piping, valves, controls, and instrumentation. The engine-driven pump draws oil from an engine-mounted reservoir and discharges it under pressure through a filter to a header. The header feeds lubricating oil to each cylinder head rocker assembly. A drain header returns the oil to the reservoir. The electric motor-driven prelube pump serves as a backup to the engine-driven pump. When the engine is on standby, the prelube pump is used to lubricate the rocker arm assembly periodically in accordance with the engine manufacturer's recommendations.

An auxiliary lubricating oil makeup tank, external to the engine skid, is provided to supplement the engine sump capacity so that the engine can operate at nameplate continuous rating for at least 7 days without adding oil to the EDELS. The makeup to the sump is controlled automatically by level switches in the sump.

A crankcase vacuum system is provided to maintain a slight negative pressure in the crankcase. The negative pressure in the crankcase reduces oil leakage out of the engine. The system consists of an ejector driven by combustion air, an oil separator, piping, valves, and instrumentation. The ejector discharge is piped outside the diesel building.

9.5.7.2.2 Component Description

Codes and standards applicable to the EDELS are listed in Tables 3.2-1 and 9.5.7-1. Except as noted below, the safety-related portions of the EDELS are designed and constructed in accordance with quality group C and seismic Category I.

MAIN OIL PUMP - The main oil pump is driven by the engine. It is a positive displacement, rotary pump. The pump draws oil from the engine sump and delivers it under pressure to the lubricating oil system. A suction strainer is provided in the engine sump. A relief valve is built into the pump for overpressure protection. A failure of this pump constitutes an engine failure. The pump failure is detected by low lubricating oil pressure or by a rise in the bearing temperature. See Section 8.3 for the details of instrumentation.

LUBRICATING OIL COOLER - The lubricating oil cooler is a horizontal shell and tube-type heat exchanger. The essential service water leaving the jacket water heat exchanger is circulated through the tubeside of the cooler.

AUXILIARY LUBRICATING OIL MAKEUP TANK - One lubricating oil makeup tank is provided per engine. The tank is external to the engine skid and is located in the same room as the engine it serves. The tank augments the engine sump capacity to permit at least 7 days of operation of the diesel engine at nameplate continuous rating without replenishing the tank. The tank is a horizontal cylindrical type. Connections are provided on the tank for manual fill, vent, overflow, drain, and level instrumentation.

KEEPWARM PUMP AND HEATER - The keepwarm pump is a positive displacement pump, driven by an electric motor. A wye strainer is installed in the suction piping to the pump. A relief valve is provided on the pump to prevent overpressurization. The keepwarm pump circulates oil through an electric heater, which is thermostatically controlled. The pump and the heater are powered from an IE source.

ROCKER LUBRICATING OIL PUMPS - The main rocker lubricating oil pump is engine driven. A backup electric motor-driven pump is also provided. The pumps are of the positive displacement type. In addition to the relief valves built into the pumps, a pressure regulator is provided in the system to prevent overpressurization. The backup pump motor is powered from an IE source.

STRAINERS AND FILTERS - Strainers and filters are provided in the EDELS to maintain the oil purity at a level required for satisfactory operation of the diesel and to protect the positive displacement pumps in the system. All the oil to the engine lubricating oil header is delivered through a duplex basket type strainer. The keepwarm pump circulates a portion of the oil in the engine sump continuously through a filter and delivers it to the main lubricating oil system upstream of the basket strainer. The rocker lubricating oil system has a filter between the pump and the engine oil header.

The main lubricating oil strainer is a full flow, removable, basket type, duplex strainer. The strainer has a 30-micron nominal particle retention capability. The filters are the cartridge type made of cellulose with a 5-micron nominal particle retention capability. Instrumentation is provided to alarm on a high pressure differential across the filters and strainers (see Sections 8.3 and 9.5.7.5 for details).

PIPING AND VALVES - All piping in the EDELS is carbon steel. Due to the manufacturer's service and design experience the flex connections used in the EDELS are of the nonmetallic type, are designed and constructed to manufacturer's standards, and have proven reliable for the intended service. The oil flow to the lube oil cooler is controlled by a self-contained thermostatic valve. The lubricating oil makeup to the engine sump is controlled automatically by a solenoid-operated valve that is actuated by the level switches in the sump.

Section 9.2.1 describes the piping and valves associated with the essential service water system.

9.5.7.2.3 System Operation

The emergency diesel generator includes an electric motor-driven prelube/keepwarm pump as an integral part of the lube oil system. This pump circulates lube oil from the engine crankcase through a keepwarm heater and a filter, then into the main lube oil system, through a strainer, and into the engine header. During engine standby, this system provides continuous prelubrication and filtering of the oil charge at keepwarm temperature. During engine operation, this system is used for continuous filtration of the oil charge. The heater is controlled by a temperature switch. A failure in the keepwarm

system will result in a lowering of the sump oil temperature. As described in Section 8.3, this condition is monitored and alarmed locally and in the control room.

During diesel engine operation, the engine-driven main oil pump draws oil from the engine sump and delivers the oil to the engine lubricating oil header through the lube oil cooler and the main lube oil strainer. The oil header supplies oil under pressure to the engine components requiring lubrication and cooling. The oil then drains back to the sump.

Essential service water is used to cool the lubricating oil at the cooler. The oil flow to the shell side of the cooler is modulated by a self-contained thermostatic valve, so that the temperature differential between the oil inlet and outlet to the engine will remain at the design minimum. The thermostatic valve bypasses the cooler when the engine is started so that the lubricating oil is brought to normal operating temperature rapidly. The valve is designed to permit the full volume of oil flow through the engine.

During normal plant operation, the service water system through the essential service water system piping provides the cooling water to the cooler. When the diesel is started during an emergency, the essential service water system supplies the cooling water to the cooler. No cooling will be available for the time required to bring the essential service water pumps into service with the power from the diesel generators. As explained in Section 9.5.5.2.3, this time lag is less than a minute. The diesel engines are designed to operate at nameplate continuous rating without cooling water for 3 minutes.

The oil level in the engine sump is maintained automatically by the auxiliary makeup tank. Instrumentation that senses the level in the engine sump controls a solenoid valve installed in the inlet piping from the makeup tank. A manual bypass around the solenoid valve is also provided.

The engine has a separate rocker arm lubrication system that includes an electric motor-driven prelubrication pump, which is manually operated and is intended to be used prior to test starts. The rocker arm prelube pump is manually started from the engine gauge panel. The pump will be operated once every week for a period of 5 to 30 minutes. (The amount of time can be adjusted between 5 and 30 minutes by means of a built-in timer.) After operating for the preset time period, the pump will automatically shut off. It is not considered detrimental by the engine manufacturer for the rocker arms to operate with reduced oil pressure for the short period of time during which the engine is coming up to speed in an emergency start situation.

During engine operation, the rocker assembly is lubricated by the engine-driven rocker lubricating oil pump. The pump draws oil from a reservoir mounted on the engine and delivers this oil through a filter to an oil header. The header distributes the oil to the rocker assembly. A return header is provided to drain the oil to the reservoir. An electric motor-driven pump is provided as a backup to the engine-driven pump. Makeup to the rocker lube oil system is provided from the main engine lube oil system to replenish any

oil which might leak past the engine valve stems. A float valve is installed to control the oil level in the reservoir.

The rocker lube oil system is employed in all Colt-Pielstick diesel engines. This is true whether the engine is in maritime, commercial, or nuclear service. The vendor (Colt) has stated that, based on both his extensive shop testing and operational service of the Colt-Pielstick diesel engine, no cooling of the rocker lube oil is required. Additionally, since the system is not considered vital to emergency start-up of the engine, a keepwarm feature is not provided. The diesel generator building is maintained at a minimum of 60°F, which is sufficient to prevent excessive cooling of the lube oil. Temporary temperature measuring instrumentation was provided on the rocker lube oil system during start-up testing at Callaway Plant to confirm proper operation. Refer to SLNRC 84-0022 dated February 2, 1984.

The full flow strainer and the bypass filter in the keepwarm system maintain the required oil purity. Fill connections are installed in the makeup tank and the engine sump. The system will be filled, using an offskid portable pump. A temporary strainer will be included in the portable pump package during filling operations. The sump can also be filled, using the fill connection provided in the keepwarm system. When this connection is used, the oil is circulated through the bypass filter and the main oil strainer by an offskid portable pump before reaching the sump. The quality of the oil in the sump and the makeup tank can be checked, if required, by withdrawing samples through the drain connections provided.

During engine operation, a portion of the combustion air is used to drive an ejector. The ejector is designed to maintain a negative pressure in the crankcase. An oil separator is provided to ensure that the ejector discharge is oil free. Instrumentation is provided to alarm on increasing crankcase pressure and to shut down the engine automatically when the pressure exceeds a design maximum. See Section 8.3 for the instrumentation details.

In addition, explosion relief doors are provided to safeguard against any sudden pressure surges within the crankcase. The explosion relief doors are designed to relieve the vapors from the crankcase and prevent the entry of outside air into the crankcase.

Excessive leakage in the main oil system will decrease the system pressure and, as described in Section 8.3, the engine will be automatically shut down. The keepwarm system can be isolated from the main oil system. Valves are provided to isolate one section of the main oil basket strainer from the other for maintenance purposes. The sump can be isolated from the makeup tank.

There are no mechanical limitations within the EDELS that would restrict the operation of the diesel engine generator when less than full electrical generation is required.

Administrative procedures control the use of lubricating oils and their containers to prevent inadvertent addition of the wrong type of oils. Maintenance procedures ensure that lube oil replacement schedules are satisfied.

Low lube oil level in the engine lube oil sump is alarmed locally and generates a control room "diesel trouble" alarm. The auxiliary lube oil tank and the engine contain sufficient lube oil to operate for 7 days, under the worst expected operating conditions, before lube oil would have to be added.

9.5.7.3 Safety Evaluation

Safety evaluations are numbered to correspond to the safety design bases in Section 9.5.7.1.

SAFETY EVALUATION ONE - The safety-related portions of the EDELS are located in the diesel generators building. This building is designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other appropriate natural phenomena. Sections 3.3, 3.4, 3.5, 3.7(B), and 3.8 provide the bases for the adequacy of the structural design of this building.

SAFETY EVALUATION TWO - The safety-related portions of the EDELS remain functional after a safe shutdown earthquake. Sections 3.7(B).2 and 3.9(B) provide the design loading conditions that were considered. Sections 3.5, 3.6, and 9.5.1 provide the hazards analyses to assure that a safe shutdown, as outlined in Section 7.4, can be achieved and maintained.

SAFETY EVALUATION THREE - The design of the emergency diesel generators provides for complete redundancy; therefore a single failure of the EDELS portion will not compromise the diesel generators' safety function. All vital power can be supplied from either the onsite or offsite power systems, as described in Chapter 8.0.

SAFETY EVALUATION FOUR - The EDELS is initially tested with the program given in Chapter 14.0. Periodic inservice functional testing is done in accordance with Section 9.5.7.4.

SAFETY EVALUATION FIVE - Section 3.2 delineates the quality group classification and seismic category applicable to the safety-related portion of this system and supporting system. Table 9.5.7-1 shows that the component meets the design and fabrication codes given in Section 3.2. All the power supplies and control function necessary for safe function of the EDELS are Class 1E, as described in Chapters 7.0 and 8.0.

SAFETY EVALUATION SIX - Section 9.5.7.2 describes provisions made to isolate leakage or malfunction of the system components.

SAFETY EVALUATION SEVEN - The EDELS components provide adequate lubrication and cooling for the various moving parts of the emergency diesel engine to permit its

operation at nameplate continuous rating for at least 7 days without oil replenishment from external sources.

SAFETY EVALUATION EIGHT - A keepwarm system is provided in the EDELS to maintain the lubricating oil temperature in a warm condition when the engine is on standby. This facilitates a quick engine start.

9.5.7.4 Tests and Inspections

Preoperational testing is described in Chapter 14.0.

The EDELS is tested periodically along with the complete diesel generator system. This test will demonstrate the performance and structural and leaktight integrity of all the system components.

The safety-related portions of the EDELS are designed and located (to the extent practicable) to permit preservice inspection.

9.5.7.5 Instrumentation Applications

The EDELS instrumentation is designed to permit automatic operation and to provide continuous indication of the system parameters. Refer to Section 8.3 for a list of annunciators and engine trip functions associated with the EDELS.

Table 9.5.7-2 lists the indicators provided for the various system parameters.

All appropriate instruments, controls, sensors, and alarms for the diesel engine lube oil system are shown on FSAR Figure 9.5.7-1, Sheets 1 and 2.

Those lube oil temperatures, pressures, and levels which alarm locally and result in a control room "diesel trouble" light and alarm are high lube oil temperature from engine, high lube oil strainer differential pressure, low lube oil pressure to engine, low lube oil sump temperature, high lube oil filter differential pressure, lube oil level control tank high level and low level, low lube oil pressure to rocker arms, rocker lube oil filter high differential pressure, and rocker lube oil reservoir high level.

In addition to the local and control room alarm for low lube oil pressure to the engine, operation of the low lube pressure switches, in a modified two-of-four logic (depicted on Figure 8.3-5), will initiate automatic shut down of the engine. None of the other malfunctions will shutdown the engine or result in any effects which require immediate operator action. Station operating procedures give the operators guidance for responding to these alarms.

Local indication is provided for lube oil temperature to and from lube oil cooler and to and from engine, lube oil strainer differential pressure, lube oil pressure to engine, auxiliary lube oil tank level, auxiliary lube oil wye strainer differential pressure, lube oil filter

differential pressure, lube oil level control tank level, rocker lube oil filter differential pressure, and lube oil pressure to rocker arms.

9.5.8 EMERGENCY DIESEL ENGINE COMBUSTION AIR INTAKE AND EXHAUST SYSTEM

The emergency diesel engine combustion air intake and exhaust system (EDECAIES) supplies combustion air of suitable quality to the diesel engines and exhausts the combustion products from the diesel engine to the atmosphere.

9.5.8.1 Design Bases

9.5.8.1.1 Safety Design Bases

The EDECAIES is safety related and is required to function following a DBA and to achieve and maintain the plant in a safe shutdown condition.

SAFETY DESIGN BASIS ONE - The EDECAIES is protected from the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, and external missiles (GDC-2).

SAFETY DESIGN BASIS TWO - The EDECAIES remains functional after a SSE and performs its intended function following the postulated hazards of fire, internal missiles, or pipe break (GDC-3 and 4).

SAFETY DESIGN BASIS THREE - Provisions are made to allow for inservice inspection of components.

SAFETY DESIGN BASIS FOUR - To the extent practicable, the EDECAIES is designed and fabricated to codes consistent with the quality group classification assigned by Regulatory Guide 1.26 and the seismic category assigned by Regulatory Guide 1.29.

SAFETY DESIGN BASIS FIVE - The EDECAIES is designed to supply combustion air to the diesel engines and to exhaust to the atmosphere the products of combustion so that the diesel generator can be operated continuously at nameplate rating.

9.5.8.1.2 Power Generation Design Bases

The EDECAIES has no power generation design basis.

9.5.8.2 System Description

9.5.8.2.1 General Description

The EDECAIES is shown in Figure 9.5.6-1. Each emergency diesel engine has its own combustion air intake and exhaust system. The combustion air intake system for each

engine consists of intake filters, intake silencers, and piping. Separate combustion air intake manifolds are provided for the right and left banks of the cylinders. Combustion air is supplied to each manifold through an intake filter and silencer. The intake system uses the air in the diesel generator room for combustion. The air intake system is located within the diesel generator building and, as such, is not subject to adverse weather condition which could potentially block the air intake system. The diesel generators building ventilation system serves as the source of makeup air which is used for combustion air by the diesel engine. See Section 9.4.7 for a description of the ventilation system.

A portion of the combustion air from one of the engine combustion air manifolds is used to drive an ejector to maintain a negative pressure in the engine crankcase (refer to Section 9.5.7 for details).

The exhaust system for each engine consists of an exhaust silencer and piping. The products of combustion gases exhausted by the engine and piped through the silencer are discharged outside the diesel generators building approximately 50 feet above the roof.

9.5.8.2.2 Component Description

Codes and standards applicable to the EDECAIES are listed in Tables 3.2-1 and 9.5.8-1. The system is designed and constructed in accordance with the following quality group requirements: All piping within the diesel generator rooms is quality group C. The intake filter, silencers, and flexible connector in the intake piping are not commercially available to quality group C. They are, therefore, designed and constructed to the manufacturer's standards. The piping outside the diesel generators building is quality group D. Those portions of EDECAIES inside the building are seismic Category I, and those portions located outside the building are nonseismic Category I.

INTAKE FILTER - Oil-bath-type air filters are used in the combustion air intake system. The filters are installed in the same room as the engine they serve. Mist eliminator pads are installed within the filters to remove any oil mist from the filtered air. A rain shield is provided over the air inlet to each filter to minimize water carryover in the event the preaction sprinkler system installed for diesel building fire protection is activated. Water carryover into the filter does not reduce the filter efficiency. The entrapped water tends to settle and can be drawn off.

INTAKE AND EXHAUST SILENCERS - Silencers are installed in the intake system to minimize the noise level within the diesel generator room. A silencer is installed in the exhaust system to reduce the noise level outside the diesel generator room. The silencers are the inline type, constructed of carbon steel, and utilize internal baffle arrangements to reduce the level of noise emitted from the EDECAIES.

PIPING - The piping in the EDECAIES is carbon steel. Expansion joints are strategically located to accommodate the thermal growth of the exhaust piping. The piping is sized

adequately so that the total pressure drop when the engine is operating at nameplate continuous rating is within the diesel engine manufacturer's recommendations.

9.5.8.2.3 System Operation

During engine standby, minimum temperature in the diesel generator room is maintained at 60°F. The diesel generator room ventilation system provides the required combustion air when the engine is operating. As explained in Section 9.4.7, the ventilation system is designed to provide combustion air under adverse weather conditions and to perform its safety function, assuming a failure of an active component.

The products of combustion are exhausted to outside the diesel building. Each engine has an independent and separate exhaust stack. The stacks discharge the exhaust gases approximately 50 feet above the diesel building roof. The exhaust gases are released approximately 35 feet above the air intake. The intake louvers are located 65 feet horizontally from the diesel stacks. The distances between the combustion air intake and exhaust release, the high exhaust discharge velocity, and the buoyancy of the heated exhaust gases are sufficient to minimize the possibilities of diluting the combustion air with exhaust. Refer to Sections 6.4, 9.4.1, 9.4.2, and 9.4.3 for a discussion on the ingestion of exhaust gases into the ventilating system of other buildings. Refer to Figures 1.2-24 through 1.2-28 for the design features and relative locations of the intake and exhaust structures.

The stacks outside the diesel generators building are nonseismic Category I because the pressure boundary integrity of the stacks is not required for proper operation of the diesel. However, to preclude blockage of exhaust flow from the diesel engines due to a seismic event, the design of the stack meets seismic Category I criteria. The design of the supports for the stacks prevents the stacks from damaging Category I structures and/or components during a seismic event. The stacks are designed to withstand a pressure differential associated with a tornado and are separated horizontally by approximately 35 feet. With this separation, it is improbable that a tornado missile can damage both stacks (see Response to Question 430.38).

Water (rain or melted snow) which has entered the diesel exhaust systems through the exhaust stack will not accumulate in the bottom of the exhaust silencer because each silencer is provided with two drain lines which are open to allow any accumulation of water to be drained off.

The tornado and missile protection for the diesel generators building ventilation system is discussed in Section 9.4.7.

The diesel generator may be required to be operated at no load to low loads (less than 20 percent) and rated speed for extended periods. To reduce the possibility of accumulation of combustion and lube oil products in the exhaust system at low loads, the engine will be operated at 50 percent load for one 1-hour period during each subsequent

24 hours, starting with the first hour of each 24-hour period. Above 20 percent load rating, the engine may be run continuously, as required.

This method of operation is based on the manufacturer's recommendations which are now included in the instruction manual. The recommendations are based in part on past experience and in part on a 24-hour no load test conducted on a 12 cylinder Colt-Pielstock Model PC-2.0 engine. That engine successfully accepted a load after 24 hours running at no load. Based on the similarity of the PC 2.5 (SNUPPS) engine to the PC 2.0 and the manufacturer's experience with the operating characteristics of each engine type, the manufacturer concludes that the PC 2.5 engine will respond more favorably to no load operation than does the PC 2.0 engine. This is confirmed by a report which shows that a PC 2.5 engine has operated in a power plant at essentially no load for at least 24 hours.

9.5.8.3 Safety Evaluation

Safety evaluations are numbered to correspond to the safety design bases in Section 9.5.8.1.

SAFETY EVALUATION ONE - Portions of the EDECAIES are located inside the diesel building. This building is designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other appropriate natural phenomena. Sections 3.3, 3.4, 3.5, 3.7(B), and 3.8 provide the bases for the adequacy of the structural design of the building. Section 9.5.8.2 and the Response to Question 430.38 describe the protection provided for the portions of EDECAIES outside the diesel generator building against the effects of natural phenomena.

SAFETY EVALUATION TWO - The safety-related portions of the EDECAIES are designed to remain functional after a safe shutdown earthquake. Sections 3.7(B).2 and 3.9(B) provide the design loading conditions that were considered. Sections 3.5, 3.6, and 9.5.1 provide the hazards analyses to assure that a safe shutdown, as outlined in Section 7.4, can be achieved and maintained.

SAFETY EVALUATION THREE - The EDECAIES is initially tested with the program given in Chapter 14.0. Periodic inservice functional testing is done in accordance with Section 9.5.8.4.

SAFETY EVALUATION FOUR - Section 3.2 delineates the quality group classification and seismic category applicable to the safety-related portion of this system and supporting system. Table 9.5.8-1 shows that the component meets the design and fabrication codes given in Section 3.2.

SAFETY EVALUATION FIVE - The EDECAIES components are designed and arranged to provide combustion air of required quality and to exhaust the combustion products when the diesel engine is operating continuously at nameplate rating.

An ESF transformer fire would not degrade engine operation by the products of combustion being drawn into the diesel generator ventilation system which supplies diesel generator combustion air. As shown on Figure 1.2-27, the diesel ventilation intake is located in the diesel building penthouse, which is approximately 20 feet below the top of the control building. As shown on Figure 1.2-11, the ESF transformers are located to the north of the diesel intakes. The control building intervenes between the subject ESF transformers (which are at approximately grade elevation) and the diesel intake. The building wake effect of the control building and the buoyancy of the smoke and gases would tend to prevent smoke from a potential ESF transformer fire from entering the intakes. In addition, the intake louvers located on the downstream side of the penthouse (from the fire) make smoke injection even less likely.

9.5.8.4 Tests and Inspections

Preoperational testing is described in Chapter 14.0.

The EDECAIES is tested periodically, along with the complete diesel generator system. This test will demonstrate the performance, structural, and leaktight integrity of all the system components.

The safety-related portions of the EDECAIES are designed and located (to the extent practicable) to permit preservice inspection.

9.5.8.5 Instrumentation Applications

The EDECAIES instrumentation is designed to provide continuous indication of the system parameters. Refer to Section 8.0 for a list of annunciators for the EDECAIES. Section 9.4.7.5 describes instrumentation provided for the diesel engine room HVAC.

All appropriate instruments, controls, sensors, and alarms for the diesel engine intake air and exhaust systems are shown on FSAR Figure 9.5.6-1, Sheets 1 and 2.

Local indication is provided for combustion air temperature, manifold air pressure, intake filter suction pressure, and exhaust air temperature from each cylinder, for the left side before and after the turbocharger and for the right side before and after the turbocharger.

There are no instruments, controls, or sensors in the intake and exhaust air systems which will shut down the engine or, when alarmed, require immediate operator action.

9.5.9 AUXILIARY STEAM SYSTEM

The auxiliary steam system is designed to provide the steam required for plant heating and processing during plant startup, complete shutdown, and normal operation.

9.5.9.1 Design Bases

9.5.9.1.1 Safety Design Bases

The auxiliary steam system has no safety function. The location of the equipment and the routing of the piping in the auxiliary steam system are based on an evaluation of the effects of both high and moderate energy line breaks.

9.5.9.1.2 Power Generation Design Basis

POWER GENERATION DESIGN BASIS ONE - The auxiliary steam system is designed to provide the steam required for plant heating and equipment operation.

9.5.9.2 System Description

9.5.9.2.1 General Description

The auxiliary steam system is shown in Figure 9.5.9-1. The system consists of steam generation equipment, distribution headers, and condensate return equipment. The auxiliary steam is distributed throughout the plant to the components listed in Table 9.5.9-1.

Normal flow is from the auxiliary steam condensate recovery tank to the auxiliary steam condensate transfer pumps. The pumps discharge from the radwaste building to the auxiliary steam condensate recovery and storage tank. The auxiliary steam deaerator feed pumps take suction from the auxiliary steam condensate recovery and storage tank and supply the auxiliary steam deaerator. The auxiliary steam feedwater pumps take suction from the auxiliary steam deaerator and discharge to the auxiliary steam boiler or the auxiliary steam reboiler, depending on which is in operation. Steam generated by the auxiliary steam system is supplied to the plant heating system and process equipment. The condensate from this equipment is then returned to the auxiliary steam condensate recovery tank or the auxiliary steam condensate recovery and storage tank.

Boiler water quality is maintained by periodic blowdown to an atmospheric blowdown tank.

The water levels in the steam boiler, steam reboiler, and the auxiliary steam deaerator are maintained by automatic controls.

Condensate makeup to the auxiliary steam condensate recovery and storage tank is from the condensate storage tank or the demineralized water system.

Alarms for high conductivity and high radioactivity levels are provided on the condensate return from the auxiliary steam condensate recovery tank. These alarms automatically cut off the steam supply and shut down the auxiliary steam condensate transfer pumps.

Section 3.6 provides an evaluation that demonstrates that the pipe routing of the auxiliary steam system is physically separated from essential systems to the maximum extent practicable. Protection mechanisms that may be required are discussed in Section 3.6.

9.5.9.2.2 Component Description

Codes and standards applicable to the auxiliary steam system are listed in Table 3.2-1. The auxiliary steam system is designed and constructed in accordance with quality group D specifications.

AUXILIARY STEAM SYSTEM AND BOILER - The auxiliary steam boiler is an oil-fired package boiler with a rated capacity of 100,000 lb/hr of saturated steam at 125 psig. The design pressure of the steam system is 150 psig, and the system is protected from overpressure by relieving through the safety valve on the boiler.

AUXILIARY STEAM REBOILER - The auxiliary steam reboiler is a U-tube-type heat exchanger, using extraction steam or main steam with a rated capacity of 100,000 lb/hr of saturated steam at 125 psig. The design pressure of the steam system is 150 psig, and the system is protected from overpressure by relieving through the safety valve on the reboiler.

AUXILIARY STEAM DEAERATOR - The deaerator is a 100-percent-capacity tray-type unit with a vertical deaerating column and a horizontal storage section. Auxiliary steam is used to preheat the condensate water.

CONDENSATE TANKS - One 600-gallon capacity condensate recovery tank is provided to handle the condensate return in the radwaste building. One 2,500-gallon-capacity condensate recovery and storage tank is provided to handle nonradwaste condensate return and serve as surge capacity for storage of condensate fed to the deaerator.

PUMPS - Two 100-percent-capacity auxiliary steam feedwater pumps are provided which can feed either the auxiliary steamboiler or the auxiliary steam reboiler. The condensate recovery tank and the condensate recovery and storage tank each have two 100-percent-capacity transfer pumps.

9.5.9.2.3 System Operation

During normal operation of the plant, extraction steam from the main turbine is supplied to the auxiliary steam reboiler which produces auxiliary steam. Provision is also made for supply main steam to the auxiliary steam reboiler.

During plant shutdown, the oil-fired auxiliary steam boiler is used to generate auxiliary steam. The switchover from use of the auxiliary steam reboiler to the oil-fired auxiliary boiler is accomplished manually.

Operational safety features are provided within the system for the protection of plant personnel and equipment. Radiological control is inherent by supplying steam at higher pressure for those plant processes which have interface with nuclear process systems.

9.5.9.3 Safety Evaluation

The auxiliary steam system has no safety function.

9.5.9.4 Tests and Inspections

Testing of the auxiliary steam system is performed prior to plant operation.

Components of the system are continuously monitored to ensure satisfactory operation.

Periodic operation of all equipment is utilized for additional inspection, checkout, and maintenance.

9.5.9.5 Instrumentation Applications

The auxiliary steam system is provided with the necessary controls and indicators for local or remote monitoring of the operation of the system.

9.5.10 BREATHING AIR SYSTEM

The Breathing Air System (BAS) provides a dedicated source of respirable air for use during maintenance operations within, and during abnormal entry into, areas having high or potentially high concentrations of airborne radioactive contaminants. The BAS provides continuous source of clean respirable air for use with personal respiratory protection equipment, such as, air-line respirators, facepieces, hoods, helmets, or suits.

9.5.10.1 Design Bases

9.5.10.1.1 Safety Design Bases

The following safety design basis is applicable to the safety-related functions of containment isolation.

SAFETY DESIGN BASIS ONE - The containment isolation valves in the system are selected, tested, and located in accordance with the requirements of 10 CFR 50, Appendix A, General Design Criteria 54 and 56, and 10 CFR, Appendix J, Testing.

9.5.10.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - The BAS provides respirable air to hose stations located throughout the Reactor Building, Auxiliary Building, Radwaste Building, Fuel Building, and laundry decontamination facility. No connections with the existing

plant compressed air system are made due to the possible contamination from the backup nitrogen gas accumulators.

POWER GENERATION DESIGN BASIS TWO - A duplex air compressor system is utilized for reliability. A single compressor is capable of handling the expected needs for the entire plant.

POWER GENERATION DESIGN BASIS THREE - The system air receiver provides a storage volume for use following a compressor failure to allow time for the standby compressor to come up to pressure.

9.5.10.2 System Description

9.5.10.2.1 General Description

The BAS includes an air compressor package, a network of piping and numerous hose stations located throughout the radiological controlled areas (RCA), portable breathing air manifolds, and the individual respirable air equipment for the personnel working in the contaminated environment. The air compressor package includes two 100 percent capacity rotary liquid-ring air compressors with an outdoor mounted inlet air filter silencer, moisture separator and filters; a common air receiver tank; and air dryer; and all piping, valves, controls, and accessory items required for operation. The piping network includes all valves and piping required to transport respirable air to hose stations located in the Reactor Building, Auxiliary Building, Radwaste Building, Fuel Building, and the Laundry Decontamination Facility. Each hose station includes valves, a quick-connect hose coupling, and a moisture drain connection. The portable breathing air manifolds provide the interface between the BAS piping and the personnel respirable air equipment.

9.5.10.2.2 Component Description

COMPRESSORS - The air compressors for the BAS are a packaged duplex system utilizing oil free rotary liquid-ring air compressors. The air compressors are electric motor operated. Each compressor is separately mounted on a structural steel base. Furnished and mounted with each compressor are a discharge moisture separator, a discharge coalescing filter, seal-water accessories, and all interconnecting piping, valves, and other components required to operate the air compressors. A common inlet air filter-silencer for both compressors is mounted outdoors.

The capacity of each compressor is 300 scfm at a 100 psig discharge pressure.

RECEIVER TANK - The air receiver insulates the air compressors from pressure pulsations due to fluctuating system demand and together with the system supply piping provides a storage volume of respirable air for use following a compressor failure to allow time for the standby compressor to come up to pressure.

The receiver tank is a vertical welded steel, galvanized vessel designed for 125 psig working pressure and constructed to ASME Section VIII Code requirements for unfired pressure vessels. The receiver tank will be separately mounted from the other BAS equipment. Accessories supplied with the tank include a gauge glass, drain trap, safety relief valve, and pressure instrumentation. The receiver tank volume is 150 cubic feet.

AIR DRYER - The air dryer is a refrigerated type air dryer. The dryer is installed downstream of the air receiver. Compressed air entering the dryer will pass first through an air-to-air heat exchanger section where it will be precooled by the refrigerated outgoing air. Next the compressed air will pass through an air-to-refrigerant heat exchanger section where heat will be transferred from the air to the refrigerant. As the air is cooled, the water vapor will condense and be removed by a separator and automatically discharged through a drain trap. The respirable air will be cooled to a pressure dew point of 35°F.

The capacity rating of the dryer is 500 scfm at a pressure of 100 psig and an inlet temperature of 100°F.

HOSE STATIONS - Each hose station includes a shut-off valve a quick-connect hose coupling, and a moisture drain connection.

BREATHING AIR MANIFOLDS - The portable breathing air manifolds provide the interface between the BAS "hard" piping and the personnel's respiratory equipment. The manifold will be connected to the BAS piping by means of a flexible metal braided hose. The manifold will monitor inlet air pressure and control outlet air pressure individually to each of five separate outlets. These manifolds are completely portable and are moved to the hose station closest to the work area.

9.5.10.2.3 System Operation

The BAS provides a dedicated, continuous supply of respirable air for use during periods of plant operation and maintenance. The BAS is designed to meet the air-supply line requirements of Part 11 of 30 CFR for Type C supplied-air respirators.

Part 11 of 30 CFR requires a controlled flow of air to a helmet or hood of 6 to 15 scfm. When cooling is required in addition to respiratory protection, a vortex type air cooler can be used.

The branch line to each hose station is sized for 80 scfm. The BAS supply piping is sized for a cumulative total of 300 scfm. Each air compressor is sized to supply 300 scfm at a discharge pressure of 100 psig. If the system pressure should fall below a preset minimum the stand-by air compressor will automatically start and supply the respirable air.

The moisture separators, filters, and air dryer assure the air quality meets the minimum grade requirements for Type I air as set forth in the Compressed Gas Association Specification G-7.1 (Grade D or higher quality).

9.5.10.3 Safety Evaluation

Safety Evaluations are numbered to correspond to the safety design bases of Section 9.5.10.1.

SAFETY EVALUATION ONE - Sections 6.2.4 and 6.2.6 provide the safety evaluation for the system containment isolation arrangement and testability.

9.5.10.4 Tests and Inspections

After installation and prior to use, each section of the piping system will be pneumatically tested with oil free air or dry nitrogen in accordance with the requirements of ANSI B31.1. A visual inspection of each soldered joint will be made to assure that the alloy has flowed completely in and around the joint and that hardened flux has not formed a temporary seal which holds test pressure. All excess flux will be removed to allow for clear visual inspection of brazed connections. All leaks will be repaired and the section retested.

The containment penetration will be leak tested per 10 CFR 50, Appendix J.

Air compressors and associated components can be checked and operated periodically. Air filters are inspected for cleanliness, and the filter elements are replaced if they no longer perform according to specifications. A high differential pressure across the air filter indicates that the filter is dirty and should be inspected.

Samples of the respirable air will be taken and analyzed for air purity.

Inservice inspection will be performed for the safety-related portions of the system as described in the Technical Specifications.

9.5.10.5 Instrumentation Applications

The function of the instruments and controls of the BAS is to control the operation of the air compressor package and air manifolds and to alert the station operators and BAS users of any malfunctions of the system.

Controls and instruments for operation of the compressor package are mounted within control panels located at the compressor skids. Control switches and operating indicating lights are located on the panels.

Pressure indication is provided on each portable manifold. A low pressure alarm will annunciate low supply air pressure at each manifold.

TABLE 9.5.1-1 CALLAWAY PLANT POWER BLOCK DEFINITION

Power Block Structures	Fire Area
Auxiliary Building	A-1, A-2, A-3, A-4, A-5, A-6, A-7, A-8, A-9, A-10, A-11, A-12, A-13, A-14, A-15, A-16, A-17, A-18, A-19,A-20, A-21, A-22, A-23, A-24, A-25, A-26, A-27, A-28, A-29, A-30, A-33
Auxiliary Boiler Room	AB-1
Control Building	C-1, C-2, C-3, C-4, C-5, C-6, C-7, C-8, C-9, C-10,C-11, C-12, C-13, C-14, C-15, C-16, C-17, C-18, C-19, C-20, C-21, C-22, C-23, C-24, C-25, C-26, C-27,C-28, C-29, C-30, C-31, C-32, C-33, C-34, C-35, C-36, C-37
Diesel Generator Building	D-1, D-2
ESW Pump House	UNPH, USPH
Fuel Building	FB-1
Radwaste Building	RW-1
Reactor Building	RB-1
Turbine Building (Includes the Communication Corridor)	TB-1
UHS Cooling Tower	UNCT, USCT

TABLE 9.5.1-2 DELETED

TABLE 9.5.1-3 SAFE AND STABLE CRITERIA

Overview of Process

The nuclear safety goals, objectives and performance criteria of NFPA 805 are different than the previous deterministic regulations. NFPA 805 requires the licensee to maintain the reactor fuel in a safe and stable condition rather than to achieve and maintain cold shutdown. Callaway Calculation KC-26 provides the analysis to achieve safe and stable conditions and the assessment of Non-Power (NPO) operations.

Safe and Stable Conditions

Per NFPA 805 the definition of "Safe and Stable" is (Ref. NFPA 805, definition 1.6.56):
"For fuel in the reactor vessel, head on and tensioned, safe and stable conditions are defined as the ability to maintain Keff < 0.99, with a reactor coolant temperature at or below the requirements for hot shutdown for a boiling water reactor and hot standby for a pressurized water reactor. For all other configurations, safe and stable conditions are defined as maintaining Keff < 0.99 and fuel coolant temperature below boiling."

The nuclear safety goal of NFPA 805 (Ref. NFPA 805, Section 1.3.1) requires "...reasonable assurance that a fire during any operational mode and plant configuration will not prevent the plant from achieving and maintaining the fuel in a safe and stable condition" without a specific reference to a minimum event coping duration. For the plant to be in a safe and stable condition, it may not be necessary to perform a transition to cold shutdown. This is consistent with the existing analysis documented in the Callaway Plant updated Final Safety Analysis Report (FSAR) Appendix 5.4A "Safe Shutdown." Therefore, the unit may remain at or below the temperature defined by a Hot Standby plant operating state.

Results

Coping Time

The NFPA 805 Nuclear Safety Performance Criteria (NSPC) Analysis for Callaway Plant has been developed to ensure that the plant can achieve and maintain the reactor fuel in a safe and stable condition assuming that a fire event occurs during Callaway Plant Mode 1 (Power Operation), Mode 2 (Startup), Mode 3 (Hot Standby), and Mode 4 (Hot Shutdown), up to the point at which the MCC breakers for the Residual Heat Removal Loop Suction Isolation Valves, BBPV8702A, BBPV8702B, EJHV8701A, and EJHV8701B, are unlocked and closed. Refer to the FSA's (Table B-3) for the Systems and Components credited with supporting safe and stable plant conditions by fire area.

The NFPA 805 Nuclear Safety Capability Assessment (NSCA) has demonstrated that Callaway Plant can achieve and maintain safe and stable conditions for at least 10 hours with the minimum shift operating staff before having to take action to recharge the nitrogen accumulators. This initial 10 hours provides sufficient time for the Emergency Response Organization (ERO) to respond and be available to support safe and stable actions to extend Hot Standby conditions.

Coping Time Bases

The minimum 10 hour coping duration is based on the normal operating pressure band of the nitrogen accumulators that support emergency operation of the Steam Generator Atmospheric Steam Dump (ASD) valves and the Turbine Driven Auxiliary Feedwater (TDAFW) Pump to Steam Generator flow control valves. Actions required to sustain Mode 3 (Hot Standby) beyond 10 hours includes an action to recharge the backup nitrogen accumulator tanks for the ASD valves and the TDAFW Pump to Steam Generator flow control valves. Recharging the tanks requires an operator to open a manual valve in Auxiliary Building fire area A-29. Opening this manual valve is addressed in plant procedures and has been demonstrated to be feasible. Additionally, the backup nitrogen accumulator tanks may need recharging every 10 hours thereafter based on valve cycling demands. Components and/or cables associated with this action are included within the NSCA equipment list.

TABLE 9.5.1-3 (Sheet 2)

Coping Time Bases (CONT'D)

The ASD valves and TDAFW Pump to Steam Generator flow control valves are air operated with a backup nitrogen gas supply tank. On loss of Instrument Air, which is conservatively assumed for NSCA, the backup nitrogen supply is relied on to maintain valve function from the MCR. The tank capacity is based on an assumed number of valve cycles and initial normal operating pressure. The 10-hour recharge time is based on the number of valve cycles assumed for a Station Blackout plus the available margin from the lower range of the normal accumulator operating pressure band. Operator action to refill the accumulators can extend the period in which these components can be used. Operator action to refill the valve accumulators is not explicitly quantified in the PRA scenarios because of the uncertainty in the Tsw (required time for action). Deterministic analysis has shown this to be a minimum of 10 hours, but the actual time is dependent on the number of valve cycles for the scenario under consideration and could be substantially greater than 10 hours. However, even at the minimum time frame of 10 hours, these actions would be expected to be minimal contributors to risk.

Impact to Plant if Recharge Time is Exceeded

Should the nitrogen accumulator tanks lose adequate pressure inventory the valve function from the MCR would be lost. No damage to the valves would occur and they would retain their capability for full MCR function once the nitrogen tanks are recharged or instrument air recovered. Loss of the ASD function would eventually result in cycling of the steam generator code safety valves. Loss of nitrogen pressure would result in the TDAFW Pump to Steam Generator flow control valves failing open. Flow through these valves can be throttled by a manual valve. Operation in this manner is procedurally controlled and is feasible.

Methods to Maintain Safe and Stable and Extend Hot Standby Conditions

The following describes methods to maintain the safe and stable condition and related support actions:

1. Callaway Plant has design features and procedures to ensure that an adequate source of inventory is provided for decay heat removal in sustained Mode 3 (Hot Standby) conditions. If the Condensate Storage Tank inventory is depleted the TDAFW pump suction will automatically transfer to the ESW supply from the Ultimate Heat Sink. Transfer can be automatic or manual from the Main Control Room. These actions are explicitly included and quantified in the PRA.

2. RCS Pressure control is maintained by a combination of ASDs, Pressurizer Heaters, and/or Reactor Pressure Vessel Head Vent valves or PORVs. PRA does not require RCS subcooling or pressurizer water level control. PRA success criteria are based on maintaining core coverage and core cooling. Requirements to provide core cooling are RCS isolation capability, AFW supply to the SG's and heat removal from the SG's. These can be maintained for greater than 24 hours.

3. Core decay heat in Mode 3 (Hot Standby) will be rejected to the secondary plant through one or more of the Steam Generators, and then to atmosphere through the Atmospheric Steam Dump valves.

4. The Callaway Plant reactor core design ensures that Keff is maintained <0.99 while the plant is in sustained Mode 3 (Hot Standby). Gravity insertion of the control rods into the reactor core will ensure reactivity control is achieved for Mode 3 (Hot Standby) for the first 24 hours. Subsequently, maintaining Keff <0.99 for safe and stable conditions will require boration of the RCS as described in FSAR Appendix 5.4A. PRA success criteria require gravity insertion of the control rods into the core.

5. Inventory makeup to the RCS may only be required to account for expected RCS leakage and minimal RCS shrinkage as well as RCP seal injection. Callaway Plant has design features and procedures to ensure that an adequate source of borated inventory is provided for RCS inventory control in sustained Mode 3 (Hot Standby) (i.e., RCS inventory makeup from the RWST) utilizing the CVCS system. Callaway Plant has design features and procedures to ensure that an adequate method is provided for RCS inventory control in sustained Mode 3 (Hot Standby) utilizing the Reactor Pressure Vessel Head Vent valves. If RWST inventory is depleted it will be refilled using a combination of Reactor Make Up Water Storage Tank and Boric Acid Storage Tank inventories. If RCP seal cooling is provided, and RCS boundary isolation is achieved (i.e., isolation of letdown, head vents, excess letdown, and pressurizer PORVs), RCS inventory makeup is not required in the PRA. For failure of seal cooling or loss of RCS boundary isolation, one charging pump is required. The PRA does not model refill of the RWST, but does model recirculation from the containment recirculation sump when RWST is depleted.

TABLE 9.5.1-3 (Sheet 3)

Methods to Maintain Safe and Stable and Extend Hot Standby Conditions (CONT'D)

6. Callaway Plant has design features and procedures to ensure that an adequate source of heat input is maintained for RCS pressure control in sustained Mode 3 (Hot Standby) (i.e., a minimum of 150 kW of pressurizer heater input to maintain the RCS sub-cooled) utilizing available combinations of the backup pressurizer heaters (Group A and Group B are 150 kW each). The backup pressurizer heaters are capable of being energized from emergency diesel generator power. The PRA does not require subcooling, so the pressurizer heaters are not modeled.

7. Each emergency diesel generator (EDG) is provided with a storage tank having a fuel oil capacity sufficient to operate that diesel for a period of 7 days while the EDG is supplying maximum post LOCA load demand discussed in the FSAR, Section 9.5.4.2. The maximum load demand is calculated based on the fuel consumption by one EDG for operation at continuous rating for 7 days. This onsite fuel oil capacity is sufficient to operate the DGs for longer than the time to replenish the onsite supply from outside sources. The PRA does not model replenishment of the onsite DG fuel oil supply. The 7-day supply is sufficient for all PRA sequences.

Qualitative Assessment of Risk

The fire brigade will respond to fire events within the Protected Area boundary in accordance with the guidance of EIP-ZZ-00226, "Fire Response Procedure For Callaway Plant." If the fire (non-hostile) meets the criteria of EIP-ZZ-00101, "Classification of Emergencies," an emergency declaration would be initiated. In the event of an Alert declaration or higher the Shift Emergency Response Organization (ERO) will be supplemented by the On-Site ERO within 30 minutes during normal working hours and within 90 minutes during off-normal hours. The On-Site ERO will assist the Control Room personnel with implementation of the longer term actions necessary to maintain the fuel in a safe and stable configuration. Following stabilization at Hot Standby, assessment and repair activities would commence to restore plant equipment needed to support RCS cool down in a safe and controlled manner. ERO resources will be available to assist the MCR in fire damage assessment and restoration of multiple success paths. Note that the Alternate Emergency Power supply (AEPS) is available but not credited in the NSCA.

- The actions required to maintain safe and stable conditions are limited.
- Procedures are in place for the safe and stable actions identified above.
- The 10-hour coping period provides reasonable assurance that adequate time is provided for the ERO to be available to augment the minimum plant staffing to support the longer term safe and stable actions.

For the most limiting fire scenarios, it is anticipated that the end state of the cool down would be an RCS temperature of approximately 350 F with a long term strategy for reactivity, decay heat removal, and inventory control. Long term subcooled natural circulation decay heat removal is provided by supplying ESW to the Steam Generators and steaming to atmosphere. The extended coping period at these conditions is based on the significant volume of water available for decay heat removal and reduced need for primary make up to match the RCS system losses. The ERO provides sufficient resources for assessment of fire damage and completion of repairs to equipment necessary to maintain hot standby for an extended period, transition to cold shutdown, or return to power operations as dictated by the plant fire event.

Conclusions

The initial coping time is sufficient to allow the ERO to activate. Limited actions are required and procedures are in place for those actions to maintain extended hot standby conditions. The ERO provides adequate capability to extend initial Hot Standby conditions, to transition to cold shutdown, or return to power operations as dictated by the plant fire event. The approach described above has demonstrated the capability to achieve and maintain the reactor fuel in a safe and stable condition for an indefinite period following a fire. A qualitative risk assessment has been performed for this scenario, which demonstrated that the risk of not being able to maintain the defined safe and stable conditions is acceptably low beyond the defined coping time limit.

TABLE 9.5.1-3 (Sheet 4)

Safe and Stable Conditions / Non-Power Operations Assessment interface

The Callaway Plant NFPA 805 Non-Power Operations Assessment provides reasonable assurance the reactor fuel is maintained in a safe and stable condition for fires which may occur in Mode 4 (Hot Shutdown) from the point at which the Motor Control Center (MCC) breakers for the Residual Heat Removal Loop Suction Isolation Valves, BBPV8702A, BBPV8702B, EJHV8701A, and EJHV8701B, are unlocked and closed, Mode 5 (Cold Shutdown) and Mode 6 (Refueling).

TABLE 9.5.3-1 DELETED

TABLE 9.5.4-1 EMERGENCY DIESEL ENGINE FUEL OIL STORAGE AND TRANSFER SYSTEM COMPONENT DATA

Underground Storage Tanks	
Quantity	2
Type	Horizontal, cylindrical
Capacity gallons, (each)	100,000
Operating pressure/temperature, psig/F	Atm/35 to 80
Design pressure/temperature, psig/F	Atm/120
Material	Carbon steel
Code	ASME Section III, Class 3
Seismic design	Category I
Fuel Oil Transfer Pumps	
Quantity	2
Type	Horizontal, centrifugal submersible
Capacity, gpm (each)	15
TDH, ft	75
NPSH required/available	Flooded suction
Material	
Case	Type 316 stainless steel
Impeller	Type 316 stainless steel
Shaft	Type 316 stainless steel
Design Code	ASME Section III, Class 3
Driver	
Type	Canned electric motor
Kilowatts, kW	2.5 with 1.15 service factor
Power supply	460 V, 60 Hz, 3-phase Class 1E
Seismic design	Category I
Emergency Fuel Oil Day Tanks	
Quantity	2
Type	Horizontal, cylindrical
Capacity gallons, (each)	600
Operating pressure/temperature, psig/F	Atm/100
Design pressure/temperature, psig/F	5/150
Material	Carbon steel
Code	ASME Section III, Class 3
Seismic design	Category I
Piping, Fittings, and Valves	
Design pressure, psig	150
Design temperature, F	100
Material	Carbon steel

TABLE 9.5.4-1 (Sheet 2)

Design code	
Safety-related portion	ASME Section III, Class 3
Nonsafety-related portion	ANSI B31.1

TABLE 9.5.4-2 EMERGENCY DIESEL ENGINE FUEL OIL STORAGE AND TRANSFER SYSTEM INDICATING AND ALARM DEVICES

	Indication		Alarm	
Indication Alarm	Control Room	Local	Control Room	Local
Storage tank level	Yes	Yes	Yes	No
Day tank level	Yes	Yes	Yes	No
Transfer pump motor-running lights	Yes	Yes	Yes	No
Fuel oil pressure	No	Yes	Yes*	Yes
Strainer/filter differential pressure	No	Yes	Yes*	Yes

* Common alarm in the control room for local annunciation.

TABLE 9.5.4-3 COMPARISON OF THE DESIGN TO REGULATORY POSITIONS OF REGULATORY GUIDE 1.137, REVISION 0, DATED JANUARY 1978, "FUEL-OIL SYSTEMS FOR STANDBY DIESEL GENERATORS"

Regulatory Guide 1.137 Position	Union Electric
1. The requirements for the design of fuel-oil systems for diesel generators that provide standby electrical power for a nuclear power plant that are included in ANSI N195-1976, "Fuel Oil Systems for Standby Diesel Generators,"[1] provide a method acceptable to the NRC staff for complying with the pertinent requirements of General Design Criterion 17 of Appendix A to 10 CFR Part 50, subject to the following:	
a. Throughout ANSI N195-1976, other documents required to be included as part of the standard are either identified at the point of reference or described in Section 7.4, "Applicable Codes, Standards, and Regulations," or Section 11, "References," of the standard. The specific acceptability of these listed documents has been or will be addressed separately in other regulatory guides or in Commission regulations, where appropriate.	a. No response is required.
b. Section 1, "Scope" of ANSI N195-1976 states that the standard provides the design requirements for the fuel-oil system for standby diesel generators and that it sets forth other specific design requirements such as safety class, materials, physical arrangement, and applicable codes and regulations. The standard does not specifically address quality assurance, and in this regard ANSI N195-1976 should be used in conjunction with Regulatory Guide 1.28, "Quality Assurance Program Requirements (Design and Construction)," which endorses ANSI N45.2-1971, "Quality Assurance Program Requirements for Nuclear Power Plants," for the design, construction, and maintenance of the fuel-oil system.	b. Complies.

TABLE 9.5.4-3 (Sheet 2)

Regulatory Guide 1.137 Position	Union Electric
c. Section 5.4, "Calculation of Fuel Oil Storage Requirements," of the standard sets forth two methods for the calculation of fuel-oil storage requirements. These two methods are (1) calculations based on assuming the diesel generator operates continuously for 7 days at its rated capacity, and (2) calculations based on the time-dependent loads of the diesel generator. For the time-dependent load method, the minimum required capacity should include the capacity to power the engineered safety features. Applications that use the time-dependent load method to calculate fuel-oil storage requirements will be reviewed on a case-by-case basis along with the calculations.	c. Complies with (1).
d. Section 7.3, "Physical Arrangement," of ANSI N195-1976 states that "the location of the day tanks of standby diesel generators shall be as required by the diesel-engine manufacturer." In addition to this requirement, the day tanks should be located at an elevation to ensure adequate net positive suction head at the engine fuel pumps at all times.	d. Complies.

TABLE 9.5.4-3 (Sheet 3)

Regulatory Guide 1.137 Position	Union Electric
e. Section 7.3 of ANSI N195-1976 states that the arrangement of the fuel-oil system "shall provide for inservice inspection and testing in accordance with ASME Boiler and Pressure Vessel Code, Section XI, 'Rules for In-Service Inspection of Nuclear Power Plant Components.'"[2] Although Section XI of the ASME Boiler and Pressure Vessel Code does not specify whether its provisions apply to fuel-oil systems, they should be applied for the inservice inspection and testing program for those portions of the fuel-oil systems for standby diesel generators that are designed to Section III, Subsection ND of the Code.	e. Complies.
f. Section 7.3 of ANSI N195-1976 states that adequate heating shall be provided for the fuel-oil system. Assurance should be provided that fuel oil can be supplied and ignited at all times under the most severe environmental conditions expected at the facility. This may be accomplished by use of an oil with a "Cloud Point" lower than the 3-hour minimum soak temperature (Ref. 1) expected at the site during the seasonal periods in which the oil is to be used, and/or by maintenance of the onsite fuel oil above the "Cloud Point" temperature.	f. Complies.

TABLE 9.5.4-3 (Sheet 4)

Regulatory Guide 1.137 Position	Union Electric
g. Section 7.5, "Other Requirements," of the standard states that "protection against external and internal corrosion shall be provided" for the fuel-oil system. To amplify this requirement for buried supply tanks not located within a vault and other buried portions of the system, a waterproof protective coating and an impressed current-type cathodic protection system should be provided in accordance with NACE Standard RP-01-69 (1972 Revision), "Recommended Practice-Control of External Corrosion on Underground or Submerged Metallic Piping Systems."[3] In addition, the impressed current-type cathodic protection system should be designed to prevent the ignition of combustible vapors or fuel oil present in the fuel-oil systems for standby diesel generators.	g. Complies.
h. Section 7.5 of the standard includes requirements for fire protection for the diesel-generator fuel-oil system. The requirements of Section 7.5 are not considered a part of this regulatory guide since this subject is addressed separately in more detail in other NRC documents. Thus a commitment to follow this regulatory guide does not imply a commitment to follow the requirements of Section 7.5 concerning fire protection.	h. Complies. See Section 9.5.1.
2. Appendix B to ANSI N195-1976 should be used as a basis for a program to ensure the initial and continuing quality of fuel oil as supplemented by the following:	

TABLE 9.5.4-3 (Sheet 5)

Regulatory Guide 1.137 Position	Union Electric
a. The oil stored in the fuel-oil supply tank, and the oil to be used for filling and refilling the supply tank, should meet the requirements of ASTM D975-74, "Standard Specification for Diesel Fuel Oils,"[4] or the requirements of the diesel-generator manufacturer, if they are more restrictive, as well as the fuel-oil total insolubles level specified in Appendix B of the standard and the "Cloud Point" requirements given in Regulatory Position C.2.b. Fuel oil contained in the supply tank not meeting these requirements should be replaced in a short period of time (about a week).	a. Complies, except that ASTM D975-81 will be used in lieu of ASTM D975-74 and Union Electric will not test for fuel oil total insolubles level as specified in Appendix B of the standard. See b and c below. Stored and new fuel oil is sampled and analyzed in accordance with the Diesel Fuel Oil Testing Program. Completion times for restoring stored fuel oil properties within limits are specified in the Technical Specifications.
b. Prior to adding new fuel oil to the supply tanks, tests for the following properties should be conducted: (1) Specific or API gravity (2) Cloud Point (3) Water and Sediment (4) 90% Distillation Temperature The fuel oil should meet the requirements of ASTM D975-74 for the latter two analyses. The "Cloud Point" should be less than or equal to the 3-hour minimum soak temperature, or the minimum temperature at which the fuel oil will be maintained during the period of time that it will be in storage. Analysis of the other properties of the fuel oil listed in ASTM D975-74 should be completed within 2 weeks of the transfer.	b. Complies, except prior to adding new fuel oil to the supply tanks viscosity will be performed instead of cloud point, and flashpoint instead of 90% distillation temperature. ASTM D975-81 will be used in lieu of ASTM D975-74. The fuel oil should meet the requirements of ASTM D975-81 for viscosity and flashpoint and for water and sediment. Analysis of the other properties of the fuel oil listed in ASTM D975-81 should be completed within 31 days instead of 2 weeks of the transfer. New fuel oil is sampled in accordance with the Diesel Fuel Oil Testing Program.

TABLE 9.5.4-3 (Sheet 6)

Regulatory Guide 1.137 Position	Union Electric
c. The periodic sampling procedure for the fuel oil should be in accordance with ASTM D270-1975, "Standard Method of Sampling Petroleum and Petroleum Products."[5]	c. Complies, except ASTM D4057 should be used in lieu of ASTM D270-1975 for the periodic sampling procedure. Periodic sampling of fuel oil is in accordance with the Diesel Fuel Oil Testing Program.
d. Accumulated condensate should be removed from storage tanks on: (1) a quarterly basis; (2) a monthly basis when it is suspected or known that the ground water table is equal to or higher than the bottom of buried storage tanks; and (3) one day after the addition of new fuel.	d. Complies, except Union Electric will not remove accumulated condensate from storage tanks one day after the addition of new fuel.
e. Day tanks and integral tanks should be checked for water monthly, as a minimum, and after each operation of the diesel where the period of operation was 1 hour or longer. Any accumulated water should be removed immediately. If it is suspected that water has entered the suction piping from the day or integral tank, the entire fuel-oil system between the day or integral tank and the injectors should be flushed.	e. Complies.
f. As a minimum, the fuel oil stored in the supply tanks should be removed, the accumulated sediment removed, and the tanks cleaned in order to perform the ASME Section XI, Article IWD-2000, "Examination Requirements," at the required 10-year intervals. To preclude the introduction of surfactants in the fuel system, this cleaning should be accomplished using sodium hypochlorite solutions or its equivalent rather than soap or detergents.	f. Complies.

TABLE 9.5.4-3 (Sheet 7)

Regulatory Guide 1.137 Position	Union Electric
g. Assuming an unlikely event should occur that would require replenishment of fuel oil without the interruption of operation of the diesel generators, the method of adding additional fuel oil should be such as to minimize the creation of turbulence of the accumulated residual sediment in the bottom of the supply tank since stirring up this sediment during the addition of acceptable new incoming fuel has the potential of causing the overall quality of the fuel oil in the storage tank to become unacceptable.	g. Complies. Refer to 9.5.4.2.1, 9.5.4.2.3 and Q430.14.
h. Cathodic protection surveillance should be conducted according to the following procedures:	h. Complies.
(1) At intervals not exceeding 12 months, tests should be conducted on each underground cathodic protection system to determine whether the protection is adequate.	
(2) The test leads required for cathodic protection should be maintained in such a condition that electrical measurements can be obtained to ensure the system is adequately protected.	
(3) At intervals not exceeding 2 months, each of the cathodic protection rectifiers should be inspected.	
(4) Records of each inspection and test should be maintained over the life of the facility, to assist in evaluating the extent of degradation of the corrosion protection systems.	

NOTES:

1. Copies may be obtained from the American Nuclear Society. 555 North Kensington Avenue, La Grange Park, Illinois 60525.

TABLE 9.5.4-3 (Sheet 8)

2. Copies may be obtained from the American Society of Mechanical Engineers. United Engineering Center. 345 East 47th Street, New York, N.Y. 10017.

3. Copies may be obtained from the National Association of Corrosion Engineers, 2400 West Loop South, Houston, Texas 77027.

4. Also designated ANSI Z11.205-1975. Copies may be obtained from the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

5. Also designated ANSI Z11.33-1976. Copies may be obtained from the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

TABLE 9.5.5-1 EMERGENCY DIESEL ENGINE COOLING WATER SYSTEM COMPONENT DATA (PER DIESEL ENGINE)

Jacket Cooling Water Pump	
Quantity	1
Type	Horizontal centrifugal
Capacity, gpm	1,054
TDH, ft	128
Design code	MS
Driver	Engine driven
Seismic design	Category I
Jacket Coolant Keepwarm Pump	
Quantity	1
Type	Canned Pump
Capacity, gpm	50
TDH, ft	20
Design code	ASME Section III, Class 3
Driver	
Type	Electric motor
Horsepower, hp	2
Rpm	1,750
Power supply	460 V, 60 Hz, 3-phase Class 1E
Design Code	NEMA
Seismic design	Category I
Jacket Cooling Water Heat Exchanger	
Quantity	1
Type	Horizontal shell and tube
Design duty, Btu/hr	7.24×10^6
Seismic design	Category I
Codes and standards	ASME Section III, Class 3 TEMA R
Tube side:	
Fluid	Service water/essential service water
Temperature in/out, F	105/119
Flowrate, gpm	1,200
Design pressure, psig	200
Design temperature, F	200

TABLE 9.5.5-1 (Sheet 2)

Material:	
Tubes	AL-6XN® ASME SB-676, Class 2, UNS N08367
Tubesheet	Stainless steel ASME SA182 F316/L
Shell side:	
Fluid	Jacket cooling water
Temperature in/out, F	180/165
Flowrate, gpm	1,050
Design pressure, psig	150
Design temperature, F	200
Material	Carbon steel
Jacket Coolant Keepwarm Heater	
Quantity	1
Type	Electric
Design rating, kW	42
Power supply	480 V, 60 Hz, 3 phase Class 1E
Code (pressure boundary)	ASME Section III, Class 3
Seismic design	Category I
Expansion Tank	
Quantity (per engine)	1
Type	Horizontal, cylindrical
Capactiy, gallon	100
Operating pressure/temperature, psig/F	Atm./122
Material	Carbon steel
Code	ASME Section III, Class 3
Seismic design	Category I
Intercooler Cooling Water Pump	
Quantity (per engine)	1
Type	Horizontal centrifugal
Capacity, gpm	1,063
TDH, ft	126
Design code	MS
Driver	Engine driven
Seismic design	Category I
Intercooler Heat Exchanger	
Quantity (per engine)	1
Type	Horizontal shell and tube
Design duty, Btu/hr	4.8×10^6
Seismic design	Category I

TABLE 9.5.5-1 (Sheet 3)

Codes and standards	ASME Section III, Class 3, TEMA R
Tubeside:	
Fluid	Service water/essential service water
Temperature in/out, F	95/105
Flowrate, gpm	1,200
Design pressure, psig	200
Design temperature, F	200
Material:	
Tubes	AL6XN®ASME SB-676, Class 2, UNS No8367
Tubesheet	AL6XN®ASME SB-688, Class 2, UNS No8367
Shell side:	
Fluid	Intercooler cooling water
Temperature in/out, F	121/110
Flowrate, gpm	1,063
Design pressure, psig	150
Design temperature, F	200
Material	Carbon steel
Piping, Fittings, and Valves	
Material	Carbon steel
Design code	
Safety-related portion (except flexible connectors)	ASME Section III, Class 3
Flexible connectors	MS
Seismic design	Category I

TABLE 9.5.6-1 EMERGENCY DIESEL ENGINE STARTING SYSTEM COMPONENT DATA

Compressors	
Quantity (per engine)	2
Type	Reciprocating, air cooled
Capacity, scfm	31
Discharge pressure, psig	700
Air temperature leaving cooler, F	160
No. of stages	3
Design code	MS
Driver	
Type	Electric motor
Horsepower, hp	15
Rpm	1,800
Power supply	480 V, 60 Hz, 3 phase non-IE
Seismic design	Nonseismic Category I
Dryers	
Quantity (per engine)	2
Type	Desiccant, automatic regenerative
Capacity, scfm	31 scfm
Design pressure, psig	700
Air inlet temperature, F	122
Dew point of air leaving dryer, F	(-)40
Afterfilter capacity	100% for 0.9 micron, 98% for 0.07 micron
Design code	MS
Seismic design	Nonseismic Category I
Starting Air Tanks	
Quantity (per engine)	2
Type	Horizontal, cylindrical
Capacity, cu ft	55
Design pressure/temperature psig/F	700/200
Operating pressure/temperature, psig/F	640/122
Material	Carbon steel
Code	ASME Section III, Class 3
Seismic design	Category I
Piping, Fittings, and Valves (Safety Related)	
Material	Carbon steel
Design code	ASME Section III, Class 3
Seismic design	Category I

TABLE 9.5.6-1 (Sheet 2)

Piping, Fittings, and Valves (Nonsafety Related)	
Material	Carbon steel
Design code	MS

TABLE 9.5.7-1 EMERGENCY DIESEL ENGINE LUBRICATION SYSTEM COMPONENT DATA

Main Oil Pump	
Quantity, (per engine)	1
Type	Positive displacement, rotary
Design Capacity, gpm	631
Nominal Capacity, gpm	420
Relief valve set pressure, psig	110-115
Design code	MS
Driver	Engine driven
Seismic design	Category I
Keepwarm Pump	
Quantity (per engine)	1
Type	Positive displacement, rotary
Capacity, gpm	75
Relief valve set pressure, psig	130
Design code	MS (Note 1)
Driver	
Type	Electric motor
Horsepower, hp	15
Rpm	1,200
Power supply	460 V, 60 Hz, 3 phase Class 1E
Design code	NEMA
Seismic design	Category I
Oil Cooler	
Quantity, (per engine)	1
Type	Horizontal shell and tube
Design duty, Btu/hr	2.2×10^6
Codes and standards	ASME Section III, Class 3 TEMA R
Seismic design	Category I
Tubeside:	
Fluid	Service water/essential service water
Temperature in/out, F	119/123
Flowrate, gpm	1,200
Design pressure, psig	200
Design temperature, F	200
Material	
Tubes	AL-6XN® ASME SB-676, Class 2, UNS N08367

TABLE 9.5.7-1 (Sheet 2)

Tubesheet	Stainless steel ASME SA182 F316/L
Shellside:	
Fluid	Lubricating oil
Temperature in/out, F	160/138
Design Flowrate, gpm	631
Nominal Flowrate, gpm	420
Design pressure, psig	150
Design temperature, F	200
Material	Carbon steel
Keepwarm Heater	
Quantity, (per engine)	1
Type	Electric
Design rating, kW	24
Power supply	480 V, 60 Hz, 3 phase Class 1E
Code (pressure boundary)	ASME Section III, Class 3
Seismic design	Category I
Makeup Tank	
Quantity, (per engine)	1
Type	Horizontal, cylindrical
Capacity, gallon	300
Operating pressure/temperature, psig/F	Atm./amb.
Material	Carbon steel
Code	ASME Section III, Class 3
Seismic design	Category I
Main Oil Strainer	
Quantity, (per engine)	1
Type	Duplex, removable basket type
Design Flowrate, gpm	700
Nominal Flowrate, gpm	490
Particle retention capability	30 micron (nominal)
Design pressure/temperature,	56 micron (absolute)
psig/F	150/200
Material	
Screen	Stainless steel
Housing	Carbon steel
Code (pressure boundary)	ASME Section III, Class 3
Seismic design	Category I
Bypass Filter	

TABLE 9.5.7-1 (Sheet 3)

Quantity, (per engine)	1
Type	Cartridge type, simplex
Flowrate, gpm	75
Design pressure temperature, psig/F	150/200
Filtering capacity, microns	5 (nominal)
Material	
Housing	Carbon steel
Filter	Cellulose
Code (pressure boundary)	ASME Section III, Class 3
Seismic design	Category I
Rocker Lube Oil Pump	
Quantity, (per engine)	1
Type	Rotary, positive displacement
Capacity, gpm	2.2
Relief valve set pressure, psig	20
Design code	MS
Driver	Engine driven
Seismic design	Category I
Rocker Prelube Pump	
Quantity, (per engine)	1
Type	Rotary, positive displacement
Capacity, gpm	2.2
Relief valve set pressure, psig	20
Design code	MS
Driver	
Type	Electric motor
Horsepower, hp	0.5
Rpm	1,200
Power supply	460 V, 60 Hz, 3 phase Class 1E
Design code	NEMA
Seismic design	Category I
Rocker Lube Oil System Filter	
Quantity, (per engine)	1
Type	Cartridge
Flowrate, gpm	2.5
Design pressure/temperature, psig/F	25/200
Capacity, microns	5
Material	

TABLE 9.5.7-1 (Sheet 4)

Housing	Carbon steel
Filter	Cellulose
Design code	MS
Seismic design	Category I
Piping, Fittings, and Valves	
Material	Carbon steel
Design code	
Safety-related portion (except flexible connectors)	ASME Section III, Class 3
Flexible connectors	MS
Seismic design	Category I

Note 1. These pumps do not carry an N-stamp; however, they are designed and procured with appropriate controls to ensure equivalency to ASME Section III, Class 3, Seismic Category I, Quality Group C requirements.

TABLE 9.5.7-2 EMERGENCY DIESEL ENGINE LUBRICATION SYSTEM INDICATING DEVICES

Indication	Local Panel Mounted	Engine Skid Mounted
Oil pressure to engine header	Yes	No
Oil pressure from engine	No	No
Oil temperature to engine header	Yes	No
Oil cooler inlet temperature	No	Yes
Oil cooler outlet temperature	No	Yes
Main oil strainer differential pressure	No	Yes
Bypass filter differential pressure	No	Yes
Keepwarm pump suction strainer differential pressure	No	Yes
Sump oil level	Yes	No
Makeup tank oil level	Yes	No
Rocker oil header pressure	Yes	No
Rocker oil filter differential pressure	No	Yes
Crankcase pressure	Yes	Yes

TABLE 9.5.8-1 EMERGENCY DIESEL ENGINE COMBUSTION AIR INTAKE AND EXHAUST SYSTEM COMPONENT DATA

Air Intake Filter	
Quantity (per engine)	2
Type	Oil bath
Design flow, cfm	
Design pressure/temperature, psig/F	
Material	Carbon steel
Quantity of oil, gals	59
Code	MS
Seismic design	Category I
Intake Silencer	
Quantity (per engine)	2
Type	Horizontal
Design flow, cfm	
Design pressure/temperature, psig/F	
Material	Carbon steel
Code	MS
Seismic design	Category I
Exhaust Silencer	
Quantity (per engine)	1
Type	Horizontal
Design flow, cfm	
Design pressure/temperature, psig/F	
Material	Carbon steel
Code	MS
Seismic design	Category I
Piping	
Material	Carbon steel
Design code	
Inside diesel building (except flexible connectors in the intake piping)	ASME Section III, Class 3
Flexible connectors (intake)	MS
Outside the building	ANSI B31.1
Seismic design	Category I

TABLE 9.5.9-1 COMPONENTS SUPPLIED BY AUXILIARY STEAM

	Component	Referenced Section	Steam Rate ($x 10^4$ lb/hr)
a.	Plant heating heat exchanger	9.4.9	1.966
b.	Deleted		
c.	Deleted		
d.	Outdoor storage tank heating	6.3, 9.2	0.066
e.	Turbine steam seal system	10.4.3	1.9-3.4
f.	Deleted		
g.	Condenser sparging	10.4.1	2.75
h.	Boric acid batching tank	9.3.4	0.05
i.	Auxiliary feedwater turbine-driven pump (preoperational testing only)	10.4.9	1.2
j.	S.G.F.P. turbine A & B (preoperational testing only)	10.4.7	2.4
k.	Decontamination areas in the auxiliary building and containment	N/A	0.2
l.	Domestic hot water heater	9.4.9	1.08
m.	Moisture separator reheater tube blanketing	10.2	0.2
n.	Turbine shell/main-steam control valve chest	N/A	1.5

TABLE 9.5.10-1 COMPONENT DESCRIPTION BREATHING AIR SYSTEM

Component	
Air Compressors	
Type	Rotary Liquid Ring
Quantity	2
Capacity (scfm) ea.	300
Disch. Press. (psig)	100
Motor Horsepower	200
Discharge Air Filters	
Type	cartridge, disposable
Quantity	2 for each compressor
Capacity (scfm) ea.	300
Air Receiver	
Type	Vertical
Quantity	1
Capacity (cu. ft.)	150
Operating Press. (psig)	100
Design Press. (psig)	125
Code	ASME Sect. VIII
Air Dryer	
Type	Refrigerant
Quantity	1
Capacity (scfm)	532
Operating Press. (psig)	100
Design Press. (psig)	200
Portable Air Manifolds	
Type	Single Inlet-Multiple Outlet
Quantity	12
Inlet Capacity (scfm)	75
No. of Outlets	5
Outlet Capacity (scfm) ea.	15
Operating Press. (psig)	100
Design Press. (psig)	150

APPENDIX 9.5A - DELETED

Appendix 9.5B - Deleted

TABLE 9.5B-1 DELETED

TABLE 9.5B-2 DELETED

TABLE 9.5B-3 DELETED:

TABLE 9.5B-4 DELETED

APPENDIX 9.5C - DELETED

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APPENDIX 9.5D - DELETED

APPENDIX 9.5E DELETED