Millstone Power Station Unit 3
Safety Analysis Report

Chapter 9: Auxiliary Systems

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CHAPTER 9 - AUXILIARY SYSTEMS

9.1 FUEL STORAGE AND HANDLING

Millstone 3 has chosen to comply with 10 CFR 50.68(b) concerning criticality accident requirements.

9.1.1 NEW FUEL STORAGE

9.1.1.1 Design Bases

The new fuel storage vault facility at Millstone Unit No. 3 has a total storage capacity of 96 fuel assemblies. The storage locations are divided into four identical modules, each containing 24 locations in a 4 by 6 array. Each storage location consists of upper and lower steel guides holding a square tube into which an assembly is placed. Two rows of 0.005 g/cm^2 B^{10} Boral sheets are located in each of the four modules. The arrangement of the storage racks in the new fuel vault is shown in Figure 9.1–18.

The fuel storage racks have two basic components: the support structure and the fuel storage cell. The support structure consists primarily of two horizontal grids which are supported by the four corner angles and which maintain the horizontal position and vertical alignment of “free” storage cells. The “free” storage cells rest directly on the new fuel vault floor. Diagonal bracing is provided on the structure to accommodate the loads imposed by rack installation. A schematic drawing of a 6 by 4 rack is shown in Figure 9.1–19.

Each storage cell is nominally 8-15/16 inches square (I.D.) by 168 inches long with 0.090 inch walls. The cells are flared at the top to aid in insertion of the fuel assembly into the cell. Each rack module is supported by adjustable swivel feet which raise the rack above the pool floor to the height required to ensure proper leveling of the rack.

The horizontal seismic loads are transmitted from the rack structure to the spent fuel pool walls at the grids through rigid seismic bracing. No shear loads are transmitted to the pool floor or rack support pads. The vertical dead-weight and seismic loads are transmitted directly to the pool floor by each storage cell.

9.1.1.2 Facilities Description

The new fuel storage vault is a rectangular structure located in the northwestern quadrant of the fuel building. The new fuel storage vault is 24 feet long by 15 feet 9 inches wide by 18 feet 4 inches deep with the bottom approximately 9 feet 6 inches above grade. The interior walls and floor of the vault are of reinforced concrete construction and are lined with 1/4 inch thick stainless steel plate.

9.1.1.3 Safety Evaluation of New Fuel (Dry) Storage Rack

The design and safety evaluation of the new fuel dry storage racks is in accordance with the NRC position paper, Review and Acceptance of Spent Fuel Storage Handling Applications, April 1978.

The racks are designated ANS Safety Class 3 and Seismic Category I and are designed to withstand normal and postulated dead loads, live loads, and loads caused by the operating basis earthquakes and safe shutdown earthquake events.

The design of the racks is such that K_{eff} remains less than or equal to 0.95 under normal and fully flooded (unborated water) conditions. A fuel handling accident was not analyzed because it was determined to be no credible due to the rack structure and tube covers of the new fuel storage rack. Also, the design of the racks is such that K_{eff} remains less than or equal to 0.98 under optimum moderator conditions (fully flooded with foam). Due to the use of fuel barriers and the close spacing of the cells, it is impossible to insert a fuel assembly in other than design locations or between the rack periphery and the pool wall.

The racks are also designed with adequate energy absorption capabilities to withstand the impact of a dropped fuel assembly from the maximum lift height of 5 feet over the top of the racks. The fuel storage racks can withstand an uplift force equal to 2000 pounds.

All materials used in construction are compatible with the fuel building/vault environment and all surfaces that come into contact with the fuel assemblies are made of annealed austenitic stainless steel. All the materials are corrosion resistant and do not contaminate the fuel assemblies or vault environment.

9.1.2 SPENT FUEL STORAGE

9.1.2.1 Design Bases

The spent fuel racks are designated ANS Safety Class 3 and Seismic Category I, and are designed to withstand normal and postulated dead loads, live loads, loads due to thermal effects, and loads caused by the operating basis earthquakes (OBE) and safe shutdown earthquake (SSE) events. The spent fuel pool liner and structure must sustain these loads. All rack modules are free standing and able to withstand tipping or overturning during postulated SSE events.

The design of the spent fuel racks is such that K-effective of the spent fuel pool must remain less than or equal to 0.95 under all conditions, including fuel handling accidents. Soluble boron in the spent fuel pool will be credited only for accident conditions which would not concurrently cause a boron dilution event.

The reactivity condition (K-effective) of the spent fuel pool is assured by the limiting condition for operation and surveillance requirements imposed by the Technical Specifications (Sanders). At any time, should the boron concentration be discovered to be less than the limit (as defined by the Technical Specification limiting condition for operation), then the Technical Specifications actions require the pool to be borated until the concentration meets the limit. Should an assembly be discovered in a region it is not qualified for (as defined by Technical Specification surveillance requirements), immediately initiate corrective actions to move that assembly:

1. Immediately initiate, review, and approve a special nuclear material handling document to move the fuel assembly to an acceptable fuel storage region.
2. Upon approval of the special nuclear handling document, immediately initiate actions to remove the fuel assembly from the incorrect fuel storage region per the instructions of the special nuclear material handling document.
3. In a timely manner, place the fuel assembly into an acceptable fuel storage region per the instructions of the special nuclear material handling document.

The spent fuel racks are designed to maintain the stored fuel assemblies in a safe, coolable geometry, with off site radiological dose consequences due to fuel handling events bounded by the fuel handling event described in Section 15.7.4.

The design of the spent fuel racks is in accordance with the following criteria:

1. General Design Criterion 2 (Section 3.1.2.2) as related to structures housing the racks and the racks themselves being capable of withstanding the effects of natural phenomenon, such as earthquakes.

2. General Design Criterion 5 (Section 3.1.2.44) as related to the capability to transfer heat loads from the safety related structures, systems and components (racks themselves) to a heat sink under both normal operating and accident conditions.

3. General Design Criterion 61 (Section 3.1.2.61) as related to the rack design for fuel storage and handling, including the following elements:

   - The capability for periodic inspection and testing of components important to safety.

   - Provisions for decay heat removal.

   - Suitable shielding for radiation protection.

4. General Design Criterion 62 (Section 3.1.2.62) Prevention of Criticality in fuel storage and handling, as related to the rack design.

5. USNRC Standard Review Plan, NUREG-0800, Section 9.1.2, Spent Fuel Storage, Rev. 3, July 1981.

6. USNRC letter of April 14, 1978 to all Power Reactor Licensees-OT Position for Review and acceptance of Spent Fuel Storage and Handling Applications including modification letter dated January 18, 1979.

9.1.2.2 Facilities Description

The spent fuel pool (Figure 3.8–63) is an L-shaped structure located in the southwestern quadrant of the fuel building. Two adjacent areas, which are accessible from the spent fuel pool by means of sealable gates, are the transfer canal and the spent fuel shipping cask pit.

The spent fuel pool is designed to accommodate fuel racks that store new and spent fuel assemblies. At the time of initial operation, installed capacity was at least one and one-third cores. The storage racks are located under water in the spent fuel pool.

There are three different fuel storage Regions in the spent fuel pool. The spent fuel storage pool contains 350 Region 1 storage locations, 673 Region 2 storage locations and 756 Region 3 storage locations, for a total of 1779 total available fuel storage locations. An additional Region 2 rack with 81 storage locations has been licensed by the NRC, but is not physically installed in the spent fuel pool. If this additional rack is installed, the Region 2 storage capacity is 754 storage locations. The total storage capacity of the spent fuel pool is limited to no more than 1860 fuel assemblies.

Each fuel storage Region of the spent fuel pool has a different fuel storage rack design. Each Region is described next. Figure 9.1–21 shows a layout of the spent fuel pool.

<u>Region 1</u>

The Region 1 fuel storage racks are made up of 5 rack modules. Each rack module is free standing and is made up of a 7 by 10 array of storage cells. The total capacity of Region 1 is 350 storage cells. Figures 9.1–22A, 9.1–22B, and 9.1–22C show a typical Region 1 rack. The Region 1 racks have a nominal 10.0 inch (North/South) and a nominal 10.455 inch (East/West) center to center spacing between adjacent fuel storage locations. The Region 1 storage racks have a neutron flux trap design, which uses BORAL as the active neutron absorber. BORAL panels are included on all peripheral rack locations.

BORAL is a thermal neutron poison material composed of boron carbide and an aluminum alloy. The neutron absorbing central layer of BORAL is clad with permanently bonded surfaces of aluminum. The BORAL is held within the rack by a stainless steel sheath welded to the rack wall. The BORAL panels are a minimum 148 inches in length to fully shadow the active fuel height, including the blanket region, and BORAL panels are conservatively present on all exterior rack faces.

Each rack module is provided with adjustable support legs which allow remote leveling of the rack after its placement in the spent fuel pool (Figure 9.1–24).

Each Region 1 rack designates each storage location as a Region 1A or Region 1B storage location. The two rows adjacent to the west spent fuel pool wall are designated Region 1B, and the remaining locations designated as Region 1A (Figure 9.1–22):

(1) Fuel stored in Region 1A may be fresh fuel up to 4.75 weight percent U-235 initial enrichment that contains no burnable absorber. Fuel with greater than 4.75 weight percent U-235 initial enrichment must meet either a minimum burnup requirement or a minimum IFBA loading requirement for Region 1A storage.

(2) Fuel stored in Region 1B may be fresh fuel up to 5.0 weight percent U-235 initial enrichment that contains no burnable absorber.

Region 2

The Region 2 fuel storage racks are made up of 9 rack modules. Each rack module is free standing with several different storage array sizes.

The total installed capacity of Region 2 is 673 storage cells. Figures 9.1–23A, 9.1–23B and 9.1–23C show a typical Region 2 rack. An additional (tenth) Region 2 rack with 81 storage locations has been licensed by the NRC, but is not physically installed in the spent fuel pool. If this rack is installed, the Region 2 storage capacity is 754 storage locations. The total storage capacity of the spent fuel pool is limited to no more than 1860 fuel assemblies. If this tenth rack is placed in the spent fuel pool, it would be located as shown in Figure 9.1–21.

The Region 2 racks have a nominal 9.017 inch center to center spacing between adjacent fuel storage locations. Like the Region 1 racks, the Region 2 storage racks use BORAL as the active neutron absorber. The Region 2 storage racks have a single BORAL panel between adjacent fuel assemblies. BORAL panels are included on all peripheral rack locations.

Each rack module is provided with adjustable support legs which allow remote leveling of the rack after its placement in the spent fuel pool (Figure 9.1–24).

In Region 2, fuel may be stored in all available Region 2 storage locations, provided that established limits on minimum fuel burnup as a function of maximum planar volume averaged as-built initial U-235 fuel enrichment are met. Also, a fuel assembly with an initial enrichment less than or equal to 5.0 weight percent U-235 that contains a control rod can be stored in Region 2 without restriction (e.g., fresh fuel with no integral burnable absorber).

Region 3

The Region 3 fuel storage racks are made up of 21 rack modules. Each rack module is free standing and is made up of a 6 by 6 array of storage cells. Each rack consists of cells welded to a grid base and welded together at the top through an upper grid to form an integral structure. The total capacity of Region 3 is 756 storage cells. Figures 9.1–1 and 9.1–3 show a typical Region 3 rack. The Region 3 racks have a nominal 10.35 inch center to center spacing (Figure 9.1–2) between adjacent fuel storage locations. The Region 3 storage racks have a neutron flux trap design, which uses Boraflex as the active neutron absorber. However, Boraflex is no longer credited in the criticality analysis of these racks. Each rack module is provided with adjustable leveling pads at the center of the four corner cells within the module (Figure 9.1–5).

In Region 3, fuel may be stored in all available Region 3 storage locations, provided that established limits on minimum fuel burnup as a function of maximum planar volume averaged as-built initial U-235 fuel enrichment are met. Also, the decay time of the fuel may be used to reduce the fuel burnup requirements for fuel to be stored in this region of the spent fuel pool.

9.1.2.3 Safety Evaluation of Spent Fuel Racks

The design and safety evaluation of the spent fuel racks is in accordance with the NRC position paper, Review and Acceptance of Spent Fuel Storage and Handling Applications, April 1978.

The racks are designated ANS Safety Class 3 and Seismic Category I and are designed to withstand normal and postulated dead loads, live loads, loads due to thermal effects, and loads caused by the operating basis earthquakes and safe shutdown earthquake events.

The design basis for preventing criticality in the spent fuel pool is that, considering possible variations, there is a 95 percent probability at a 95 percent confidence level that the effective multiplication factor ($K_{eff)}$ of the fuel assembly array will be less than 0.95 as recommended in ANSI N210-1976. The design of the racks is such that K_{eff} meets this design basis under all conditions, including fuel handling accidents, seismic events, and loss of fuel pool cooling.

Important aspects of the criticality safety analysis of the spent fuel storage racks are:

- Under normal and accident conditions, credit for soluble boron is taken to ensure K_{eff} remains less than 0.95. Under normal operations, K_{eff} remains less than 1.00 with no credit for boron.

- Reactivity allowances are calculated corresponding to manufacturing tolerances for important fuel and rack dimensions.

- The most reactive fuel assembly designs present in the pool are considered in the analysis.

- The SFP bulk water temperature corresponding to maximum reactivity in the normal operating temperature range is accounted for in the criticality analysis. The normal operating SFP bulk water temperature range used in the criticality analysis is 32°F to 150°F, which bounds the actual normal operating temperature range.

- For Region 1 and 2, credit is taken for BORAL neutron absorption, such that the nominal and minimum Boron-10 areal density are.0302 and.028 grams Boron-10 per square centimeter, respectively. Only the minimum B-10 areal density is credited. Region 3 takes no credit for neutron absorption by Boraflex.

- Penalties are applied for methods, uncertainties, and biases in the calculation of K_{eff}.

<u>Criticality accidents considered are</u>:

- Inadvertent single misload of a 5.0 weight percent fresh fuel assembly in a Region 1, Region 2, or Region 3 spent fuel rack, with all other storage locations containing the maximum permissible fuel reactivity.

- Inadvertent single misload of 5.0 weight percent fresh fuel assembly between Region 1 and Region 2 spent fuel racks, or between Region 2 and Region 3 spent fuel racks with all storage locations containing the maximum permissible fuel reactivity.

- Inadvertent multiple misload of 5.0 weight percent fresh fuel assemblies in each Region 1 or each Region 3 storage location assuming an infinite lattice, or a multiple misload of fuel assemblies in each Region 2 storage locations assuming an infinitely repeating 20 x 20 lattice consisting of a 6 x 4 storage array of 5.0 weight percent unpoisoned fresh fuel assemblies surrounded by 5.0 weight percent fresh fuel assemblies that contain 32 IFBA rods.

- Inadvertent fuel handling error that moves two 5.0 weight percent fresh fuel assemblies out of a spent fuel rack into close proximity.

- Dropped fuel assembly in the spent fuel racks resulting in grid damage and optimum fuel pin pitch.

- Lateral rack movement due to a seismic event.

- Boron dilution event down to 600 ppm soluble boron.

- Spent Fuel Pool temperature increase to boiling (including voiding).

Evaluation of each of the above scenarios confirms that 2600 ppm is more than sufficient to maintain K_{eff} less than or equal to 0.95. The multiple misload accident for Region 2 results in the highest K_{eff}.

The Region 3 (Westinghouse) racks are designed with adequate energy absorption capabilities to withstand the impact of a dropped fuel assembly with Rod Control Cluster Assembly (RCCA) and associated handling tool with a dry weight of up to 2,400 pounds from the maximum lift height of the spent fuel bridge and hoist. The Region 1 and Region 2 racks are also designed to ensure their functional integrity under all credible drop events in the spent fuel pool. The analyses performed demonstrate that the configuration of the fuel assemblies, storage cell geometry and neutron absorber material configuration remain consistent with the configurations used in the thermal hydraulic and criticality evaluations. Region 1 and Region 2 racks are designed with adequate energy absorption capabilities to withstand the impact of the fuel assembly, RCCA, and associated handling tool drop, assuming parameters that bound those assumed for the previously analyzed drop onto Region 3 fuel racks.

The fuel assembly drop accidents were found to produce localized damage well within the design limits for the racks. The cell geometry and the configurations of the stored fuel and neutron absorber are not compromised. Therefore, there are no resulting thermal-hydraulic or criticality concerns.

None of the analyzed scenarios result in any radiological concerns, since all parameters related to fuel damage (weight/design of fuel assembly, drop height, assembly orientation) are enveloped by those of the design basis fuel handling accident. Therefore, the radiological consequences resulting from a fuel assembly drop continue to be bounded by the design basis accident.

The new fuel handling crane, which is capable of carrying loads greater than that of a fuel assembly, is prevented by interlocks or administrative controls, or both, from carrying such loads over spent fuel in the spent fuel pool. All regions of fuel storage racks can withstand an uplift force equal to the uplift capability of the spent fuel bridge and hoist.

All materials used in construction are compatible with the spent fuel pool environment and all surfaces that come into contact with the fuel assemblies are made of annealed austenitic stainless steel. All the materials are corrosion resistant and do not contaminate the fuel assemblies or pool environment.

In order to monitor the effectiveness of the BORAL neutron absorber material used in Region 1 and 2 storage racks of the spent fuel pool, provision is made for a material monitoring program. There is no need for a Boraflex monitoring program, since Boraflex is not credited in the criticality analysis.

The BORAL coupon monitoring program includes coupons suspended on a mounting (called a "tree") placed in a designated cell and surrounded by spent fuel. Coupons will be removed from the array on a prescribed schedule and certain physical and chemical properties measured. The coupon program will use a total of 8 test coupons.

The schedule for BORAL coupon removal is just prior to the following refueling outages: refueling outage after End-of-Cycle (EOC) 8, EOC 9, EOC 10, EOC 12, EOC 15, EOC 18, EOC 21, and one spare. After Cycle 21, Millstone Unit 3 shall follow the BORAL coupon removal schedule requirements in NEI 16-03-1, Section 2.1 (References 9.1-1 and 9.1-2). For materials with known degradation or degradation mechanisms that impact the efficacy of the neutron absorber, the measurement of the areal density one every 5 years is acceptable. For materials that have been used for several years in conditions similar to the pool environment and for which stability of the material condition has been documented, the BORAL coupon removal schedule of once every 10 years is acceptable.

The coupon tree is surrounded by freshly discharged fuel assemblies at each of the first 5 refuelings following installation of the racks to assure that the coupons will have experienced a slightly higher dose than the BORAL in the racks. Beginning with the fifth refueling following installation, the fuel assemblies may remain in place for the remaining lifetime of the racks.

Evaluation of the coupons removed will provide information of the effects of the radiation, chemical and thermal environment of the pool and by inference, comparable information on the BORAL panels in the racks.

Design of the facility in accordance with Regulatory Guide 1.13 ensures adequate safety under normal and postulated accident conditions.

The methodology used in the criticality analysis is discussed in Section 4.3.2.6.

9.1.2.4 Spent Fuel Storage in an Independent Spent Fuel Storage Installation (ISFSI)

With the installation of the Millstone ISFSI, “dry” storage of Unit 3 spent fuel on the Millstone ISFSI provides an available fuel storage option. Millstone has selected the NUHOMS® spent fuel storage system as authorized per 10 CFR 72 and approved by the NRC in Certificate of Compliance Number 1004 for an Independent Spent Fuel Storage Installation.

The ISFSI is designed to accommodate on site spent fuel storage through the end of plant life including 20 year license renewal, or until transfer of the spent fuel to a DOE repository. The spent fuel storage canisters are dual purpose, design for storage in an ISFSI per 10 CFR 72 requirements and transport off site in a spent fuel shipping cask per 10 CFR 71 requirements.

The NUHOMS® system consists of reinforced concrete horizontal storage modules (HSMs) and steel dry shielded canisters (DSCs) assembled on a concrete pad within the site protected area boundary. System operation is totally passive crediting natural air circulation for cooling.

Spent fuel is selected based on the Unit 3 spent fuel strategy and the NUHOMS® Technical Specification requirements for fuel qualification. The DSC consists of a shell and basket assembly, which can accommodate 32 fuel assemblies. The DSC is inserted into a transfer cask and placed in the cask pit area of the Unit 3 spent fuel pool for fuel loading. Once loaded, the transfer cask/DSC is relocated to the cask washdown sump area for draining, drying, closure operations and decontamination. The transfer cask is utilized to transfer the loaded DSC to the ISFSI pad for loading into an HSM. The HSM array consists of precast concrete components forming a series of concrete storage modules for dry shielded canisters storing spent fuel.

9.1.3 FUEL POOL COOLING AND PURIFICATION SYSTEM

The fuel pool cooling and purification system (Figure 9.1–6) removes decay heat from spent fuel stored in the fuel pool and provides adequate clarification and purification of water in the fuel pool, refueling cavity, and refueling water storage tank. Table 9.1–1 lists the principal component design characteristics for the system. Table 9.1–2 gives the fuel pool cooling system performance characteristics. Figure 3.8–63 shows equipment locations.

9.1.3.1 Design Bases

The fuel pool cooling and purification system is designed in accordance with the following criteria:

1. General Design Criterion 2 (Section 3.1.2.2), as related to structures housing the system and the cooling portion of the system itself being capable of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods, established in Chapters 2 and 3.

2. General Design Criterion 4 (Section 3.1.2.4), with respect to structures housing the systems and the cooling portion of the system being capable of withstanding the effects of external missiles and internally generated missiles, pipe whip, and jet impingement forces associated with pipe breaks.

3. General Design Criterion 5 (Section 3.1.2.5), as related to shared systems and components important to safety being capable of performing required safety functions.

4. General Design Criterion 44 (Section 3.1.2.44), to include:

   The capability to transfer heat loads from safety related structures, systems, and components to a heat sink under both normal operating and accident conditions.

   Suitable redundancy of components so that safety functions can be performed assuming a single active failure of a component coincident with the loss of all offsite power.

   The capability to isolate components, systems, or piping, if required, so that the safety system function is not compromised.

5. General Design Criterion 45 (Section 3.1.2.45), as related to design provisions to permit periodic inspection of safety related components and equipment.

6. General Design Criterion 46 (Section 3.1.2.46), as related to the design provisions to permit operational functional testing of safety related systems or components to assure structural integrity and system leak tightness, operability, and adequate performance of active system components, and the capability of the integrated system to perform required functions during normal, shutdown, and accident situations.

7. General Design Criterion 61 (Section 3.1.2.61), as related to the system design for fuel storage and handling of radioactive materials, including the following elements:

The capability for periodic inspection and testing of components important to safety.

Provisions for containment, confinement, and filtering.

Provisions for decay heat removal.

The capability to prevent reduction in fuel storage coolant inventory under accident conditions.

8. General Design Criterion 63 (Section 3.1.2.63), as it relates to monitoring systems provided to detect conditions that could result in the loss of decay heat removal, to detect excessive radiation levels, and to initiate appropriate safety actions.

9. Regulatory Guide 1.13 (Section 1.8, Table 1.8-1), as it relates to the system design to prevent damage resulting from the SSE.

10. Regulatory Guide 1.26 (Section 1.8, Table 1.8-1), as it relates to quality group classification of the system and its components.

11. Regulatory Guide 1.29 (Section 1.8, Table 1.8-1), as it relates to the seismic design classification of system components.

12. Branch Technical Position APCSB 3-1, as it relates to breaks in moderate energy piping system outside containment.

13. The temperature of the fuel pool water is maintained at or below 150°F for the normal operating condition of the spent fuel pool.

14. The temperature of the fuel pool water should not exceed a maximum temperature of 150°F for any long-term period. The maximum peak temperature the spent fuel pool water can reach is 200°F.

15. Purity and clarity of the refueling cavity and fuel pool water is maintained to permit observation of fuel assembly handling during refueling operations.

16. Filtration and ion exchange capability are provided to remove suspended and dissolved radionuclides to allow access to required areas.

17. The fuel pool cooling system and the service water makeup lines are safety related, Seismic Category I, and are designated SC-3 and designed to the requirements of ASME III, Class 3.

18. The purification system is not safety related and is designated nonnuclear safety (NNS).

19. The spent fuel pool cooling and purification system is capable of handling the accumulated decay heat from 1960 spent fuel assemblies, which includes a full core offload of 193 fresh fuel assemblies.

20. A full core offload is designated as a normal evolution.

9.1.3.2 System Description

The spent fuel pool cooling system has been analyzed to remove the decay heat load of up to 1960 fuel assemblies and maintain a bulk pool temperature at or below 150°F using a single train of spent fuel pool cooling. A thermal-hydraulic analysis for these bounding heat loads was performed which provided bulk pool temperature curves for three scenarios, a normal full core offload heat load (Figure 9.1–7), an emergency full core offload heat load (Figure 9.1–7A) and a normal operation - loss of fuel pool cooling event (Figure 9.1–8). These curves represent the analysis performed for cooling water to the spent fuel pool cooling heat exchangers (CCP) at 95°F, the upper design temperature limit. For normal and emergency full core offloads, shorter core offload times are permitted for lower CCP temperatures as shown in Figure 9.1–20.

The thermal-hydraulic analysis assumes that outages for full core offloads will have a minimum duration of 25 days from reactor shutdown to entry into Mode 4 following core reload and that a maximum of 97 fuel assemblies recently discharged will remain in the spent fuel pool. Refueling outages outside these conditions (less than 25 days or greater than 97 assemblies) will require specific calculations to show that the spent fuel pool decay heat levels are less that or equal to 21.1×10^6 BTU/hr.

Cooling for the spent fuel pool consists of two cooling mechanisms. The first is the active cooling provided by the fuel pool heat exchangers. The spent fuel pool water flows from the fuel pool discharge through either of the two fuel pool cooling pumps and through the tube side of either fuel pool cooler, and then returns to the fuel pool. Table 9.1–2 lists the performance characteristics of the fuel pool cooling system. One fuel pool cooling pump and cooler are normally in service. Cooling for the fuel pool coolers is provided by the reactor plant component cooling water system (Section 9.2.2.1). The second mechanism is the passive cooling provided by evaporative cooling from the surface of the pool.

The purification system consists of two purification pumps, two purification prefilters, one coarse filter, one purification demineralizer, and one postfilter. This equipment is not safety related.

The purification system provides means for filtering and demineralizing the following areas:

1. The fuel pool water to improve optical clarity for ease of underwater fuel handling and to reduce radioactive contamination in the water

2. The refueling cavity water during a refueling operation to improve optical clarity for ease of underwater fuel handling, and to reduce radioactive contamination in the water

3. The water stored in the refueling water storage tank (RWST) to reduce radioactive contamination in the water (Section 6.2.2.2)

Either pump can be used with the prefilter to filter the water in the RWST, in the refueling cavity, or in the fuel pool.

The flow rate for filtration is sufficient to process the entire spent fuel pool water inventory in approximately 3 days. This water can also be purified by diverting the flow through the purification demineralizer. In addition, by operating both pumps, the system can be used to purify the fuel pool and simultaneously filter either the RWST or the refueling cavity.

The fuel pool filters and demineralizer are located in shielded cubicles to minimize operator exposure.

Permanently installed skimmers in the fuel pool and refueling cavity remove particles on the surface of the water, thus aiding optical clarity.

Some sources of impurities are corrosion products, hydroxides, and crud deposited in the reactor vessel. Fuel defects, Inconel 718, and other nickel bearing alloys are sources of soluble radionuclides. These impurities and radionuclides enter the fuel pool through the fuel transfer tube in the form of a hydrated film adhered to the spent fuel assemblies.

Normal makeup to the fuel pool, necessitated by losses due to evaporation, is primary grade water from the primary grade water system (Section 9.2.8). Borated water from the RWST can be used to fill the fuel pool at a concentration matching that used in the refueling cavity during refueling operations. Both of these systems connect to the spent fuel pool through the non-safety related purification system.

Periodic sampling from the local sample connections is performed to check the boron concentration of the fuel pool water. Boric acid can be added manually, if required, from the dry boric acid inventory to maintain the minimum boron concentration of 2600 ppm. A minimum of 2600 ppm is required whenever fuel is in the spent fuel pool.

Should low water level in the fuel pool be alarmed, the operator can stop the operating pumps and take corrective actions to locate and isolate the leak. Water from the safety related service water system can be used as an emergency supply to the spent fuel pool. Service water is normally isolated from the fuel pool by blank flanges and isolation valves in the supply pipe. Should an emergency arise, service water flow can be established after removing the blank flanges and installing a temporary spoolpiece in the pipe. In addition, water from the fire protection system and borated water from the refueling water storage tank (Section 6.22), a Seismic Category I tank, are available. Finally, a SFP make-up connection to the emergency Service Water make-up piping, downstream of the removed spool piece, provides a means for a portable diesel driven pump to deliver make-up water to the Spent Fuel Pool. This connection is a defense-in-depth design feature that is available for coping with an extended loss of AC power (ELAP) event. The location of this BDB SFP FLEX make-up connection is shown on Figure 9.1–6.

Drain lines to the purification pumps are provided at low points in the refueling cavity to remove the water remaining below the reactor vessel flange following refueling. A tap line from the drain lines leads to the containment sump. This arrangement makes it possible for water from the quench spray system and containment recirculation system which falls into the refueling cavity to feed the containment recirculation system. The valves on the tap line are open during plant operation and closed during refueling. The purification pumps transfer the water from the refueling cavity to the RWST. The spent fuel cask pool has a drain line to the purification pumps. A blank flanged, permanently installed, piping arrangement terminates in the spent fuel shipping cask storage area. Should this piping arrangement be needed, a temporary flanged spool piece can be inserted in the line to enable one of the fuel pool purification pumps to pump the water within the spent fuel shipping cask storage area either through the prefilters or through the prefilters, demineralizer, and postfilter to the boron recovery tanks (Section 9.3.5). Administrative procedures are followed to assure that the cask storage area gate is inserted in the transfer slot in the wall separating the fuel pool from the spent fuel shipping cask storage area before pumping commences. However, the design of the gate is such that even with the gate open, the fuel pool cannot be drained below the top of the active fuel region of the fuel assemblies.

Piping, valves, and components of this system making contact with the fuel pool water are austenitic stainless steel which is corrosion- resistant to the boric acid solution.

A sample connection is provided downstream of the fuel pool demineralizer for sample removal to check the gross activity, particulate matter, boric acid concentration, and component performance.

9.1.3.3 Safety Evaluation

Two full-size fuel pool cooling pumps and two full-size fuel pool coolers are provided to ensure 100 percent redundant cooling capacity. This portion of the system is Seismic Category I and Safety Class 3. The Seismic Category I cooling portion of the fuel pool cooling and purification system is independent of the nonseismic purification portion. Failure of the purification portion in an earthquake does not affect the operation of the cooling trains. Attached to the inlet of the fuel pool cooling pump suction piping is a QA Category I vortex suppressor to prevent vortexing in the fuel pool at the piping inlet.

Each pipe which enters the fuel pool has a 1/2 inch or larger vent hole drilled into the pipe to act as an anti-siphoning device or terminates at an elevation above these vent holes. These provisions prevent siphoning of the fuel pool water to uncover the spent fuel (see Figure 9.1–6).

One pump and one cooler are sufficient to maintain the pool temperatures as indicated in Table 9.1–2.

An evaluation of the capabilities of the spent fuel pool cooling system has been performed for normal and abnormal conditions.

The decay heat loads were calculated for a number of pool operating conditions at the end of pool life. These are:

1. Normal full core offload (maximum bulk pool temperature - 150°F) - the full reactor core (193 assemblies) from the end-of-life cycle is offloaded to the spent fuel pool after one year of operation at full power. The core offload rate and minimum fuel decay time prior to starting core offload to the spent fuel pool is dependent on CCP inlet temperature to the Spent Fuel Pool heat exchangers as depicted in Figure 9.1–20.

2. Emergency full core offload (maximum bulk pool temperature - 150°F) - the full reactor core (193 assemblies) from the end-of-life cycle is offloaded to the spent fuel pool after a previous outage lasting for 10 days with 36 days of operation at full power. The heat load to the spent fuel pool is fully bounded by the heat load for a normal full core offload. The core offload rate and minimum fuel decay time prior to starting core offload to the spent fuel pool is dependent on CCP inlet temperature to the Spent Fuel Pool heat exchangers as depicted in Figure 9.1–20.

3. Normal Operation/Loss of Pool Cooling - End of life core in the reactor vessel, the latest refueling load (97 assemblies) is in the spent fuel pool with 25 days (600 hours) of decay time. Following a design basis accident with loss of power, cooling to the spent fuel pool is lost for four hours before it is restored. Cooling to the pool is limited to the evaporative heat loss. Cooling water temperature prior to loss of cooling is assumed to be at the bounding limit of 95°F.

To determine the decay heat load, the fuel bundles were analyzed as being transferred to the spent fuel pool at an average rate of three bundles per hour over the time it takes to off-load the assumed fuel load.

The decay heat in the spent fuel pool is the combination of decay heat from the previously discharged fuel assemblies and the decay heat from the most recently discharged fuel assemblies. The decay heat load for cycle 1 through cycle 5 discharged fuel was modeled on historical fuel discharge data. The projected fuel discharges for cycles 6 through the end of plant life are conservatively modeled at a bounding average batch burnup of 60,000 Mwd/MtU. The projected number of fuel assemblies discharged is conservative in that the most limiting scenario (yielding the largest discharge) was used. The most limiting scenario selected was a half core loading, consisting of alternating fresh fuel batches of 97 and 96 fuel assemblies per cycle. This resulted in discharging 1960 Millstone Unit 3 fuel assemblies at the end of plant life (including the final full core discharge).

A single active failure of the spent fuel cooling system was evaluated. A failure is assumed to disable the active train of cooling and 30 minutes is required to put the standby train into service. Should this failure occur during refueling at the peak pool temperature, forced cooling would be lost for 30 minutes. In this time, spent fuel pool bulk temperature would increase to approximately 155°F before cooling was restored and spent fuel pool bulk temperature returned to below 150°F.

Following a design basis accident with loss of power, the reactor plant component cooling water system is not available to cool the spent fuel pool coolers until approximately 4 hours after the accident at which time cooling will be restored. Power from the emergency generators is not immediately available due to loading considerations. The loss of cooling to the spent fuel pool was evaluated for normal plant operation in Case 3 above where pool temperature rose to a maximum of 148.8°F. An additional analysis, which is outside the design basis of the spent fuel pool cooling system, was conducted for the loss of spent fuel pool cooling during a full core offload. The most limiting case occurs when the pool is at 150°F with the highest heat load in the pool. For this case, a pool temperature of 200°F would be reached after 4.41 hours. For all cases of a loss of pool cooling, the pool temperature is maintained below 200°F when pool cooling is restored after four hours.

The time required to re-establish Service Water to the Reactor Plant Component Cooling Water system following a LOCA is dependent upon the heat loads in the spent fuel pool. Service Water pump, strainer and discharge check valve maintenance activities are scheduled at times during the operating cycle when spent fuel pool heat loads are reduced.

For a safety grade cold shutdown, the reactor plant component cooling water system supply temperature is permitted to increase to 113°F (see Section 9.2.2.1.2). The safety grade cold shutdown analysis demonstrates that the spent fuel pool peak bulk operating temperature remains at or below 150°F for this mode of operation.

Redundant safety grade fuel pool temperature indication is provided on the main control board. Redundant safety class 3 level switches are connected to the fuel pool which alarm in the control room. They are set to provide indication before the water level falls below 23 feet above the top of the fuel racks. Piping penetration are at least 11 feet above the top of the spent fuel so that failure of inlets, outlets or accidental piping leaks cannot reduce the water below this level.

Normal makeup water to the spent fuel pool is the primary grade water system (Section 9.2.8). Should primary grade water be unavailable, makeup water can be provided from the refueling water storage tank, a Seismic Category I source (Section 6.2.2). Both of these systems connect to the spent fuel pool through the non-nuclear safety purification system. Water can also be provided from the hose station of the fire protection system near the spent fuel pool. In addition, as an additional safety feature for the unlikely event of failure of both cooling trains and loss of the sources above, a Seismic Category I, Safety Class 3 flow path is provided from the service water system (Section 9.2.1) to provide makeup water. To prevent contamination of the pool from service water during normal conditions, a spool piece is included at the fuel pool end of the piping, with a blind flange normally in place. Sufficient time exists before pool boiling to install the spool piece.

9.1.3.4 Inspection and Testing Requirements

The fuel pool level and temperature instrumentation is tested and calibrated on a periodic basis. The safety related trains are tested for operability in accordance with the Technical Specifications. Visual inspection of system components and instrumentation is conducted periodically.

Safety related components receive inservice testing and/or inspection as specified in Sections 3.9B and 6.6. In addition, containment isolation valves are tested as specified in Section 6.2.6.3.

The system is in operation during refueling and whenever spent fuel is stored in the fuel pool. Therefore, system operational tests are not required.

The spent fuel pool water is sampled weekly for pH, conductivity, boron, chloride, fluoride, turbidity, and total gamma activity. Chloride and fluoride levels must be less than 0.15 ppm each, while acceptable pH may vary between 4.2 and 10.5. Gamma activity samples, taken from the demineralizer inlet and outlet, monitor the demineralizes decontamination factor. Local differential pressure indicators across the filters and demineralizers are used to indicate when filters and resins should be replaced.

All indicators alarm at a local control panel in the fuel building. These setpoints are based upon operating experience.

Boron concentration is monitored prior to refueling operations as stated in Section 9.1.4.2.2.

9.1.3.5 Instrumentation Requirements

The fuel pool has redundant safety grade low level alarm lights and temperature indicators provided in the main control room. Nonsafety grade level indication is provided locally and high and low level alarms are provided both locally and in the main control room. Continuous nonsafety augmented quality wide range level indication is provided remotely in the Auxiliary Building.

A local temperature indicator is provided on the common fuel pool cooler inlet piping and local temperature indicators are provided on each fuel pool cooler outlet. Fuel pool cooler outlet high temperature is indicated and alarmed locally. Nonsafety grade fuel pool temperature indication is provided locally and high temperature alarms are provided both locally and in the main control room. Fuel pool cooler outlet flow is indicated, and low flow alarmed, locally. Fuel pool cooler instrumentation is nonsafety grade.

The fuel pool cooling pumps have control switches and indicating lights in the main control room. The discharges of all pumps have local pressure indicators. The cooling pumps can be operated manually either from the control room or the switchgear. The purification pumps are operated locally.

Flow through the fuel pool demineralizer is controlled automatically. Local differential pressure indicators are used across the filters and demineralizer to indicate cleanness.

Radiation monitors installed in the fuel pool area alarm both locally and in the control room. Maximum purification flow can be established in the event of an alarm.

9.1.4 FUEL HANDLING SYSTEM

9.1.4.1 Design Bases

The fuel handling system (FHS) consists of equipment and structures used for conducting the refueling operation in a safe manner; this system conforms to General Design Criteria 61 and 62 of 10 CFR 50, Appendix A.

The following design bases apply to the FHS:

1. Fuel handling devices have provisions to avoid dropping or jamming of fuel assemblies during transfer operation.

2. Handling equipment has provisions to avoid dropping of fuel handling devices during the fuel transfer operation.

3. Handling equipment used to raise and lower spent fuel has a limited maximum lift height so that the minimum required depth of water shielding is maintained.

4. The fuel transfer system (FTS), where it penetrates the containment, has provisions to preserve the integrity of the containment pressure boundary.

5. Criticality during fuel handling operations is prevented by the geometrically safe configuration of the fuel handling equipment.

6. In the event of a safe shutdown earthquake (SSE), handling equipment cannot fail in such a manner so as to damage seismic Category I equipment or spent fuel assemblies.

7. The inertial loads imparted to the fuel assemblies or core components during handling operations are less than potential damage-causing loads.

8. Physical safety features are provided for personnel who operate handling equipment.

9. The spent fuel shipping cask crane is physically prevented from bringing the spent fuel shipping cask over the spent fuel pool.

10. Provisions have been included such that a spent fuel transfer cask drop is not credible. Therefore, there will be no damage to safety related equipment or spent fuel assemblies.

11. The new fuel handling crane is equipped with interlocks such that it can not carry a load over the spent fuel pool. Administrative controls may be used in lieu of crane interlocks and physical stops for handling fuel racks, spent fuel pool gates, or loads less than 2,200 lbs.

12. Maximum kinetic energy for any load moved by light load handling systems above the spent fuel pool does not exceed the energy of a fuel assembly dropped from its normal handling height.

9.1.4.2 System Description

The FHS consists of the equipment needed for the refueling operation in the reactor core. Basically, this equipment is comprised of core component and reactor component hoisting equipment, handling equipment, and an FTS. The structures associated with the fuel handling equipment are the refueling cavity, the fuel transfer canal, and the fuel storage area.

The elevation and arrangement drawings of the fuel handling facilities are shown on Figure 3.8–63.

9.1.4.2.1 Fuel Handling Description

For new fuel handling, the 10 ton new fuel receiving crane transfers the new fuel assembly shipping containers from the delivery truck to either a storage location or a location where the 10 ton new fuel handling crane has access to the new fuel assemblies in their shipping containers. The new fuel handling crane moves the new fuel assemblies from their shipping containers to the new fuel dry storage vault and from the new fuel dry storage vault to the spent fuel pool via the new fuel elevator. New fuel assemblies received for initial core loading and subsequent fuel shipments are removed one at a time from the shipping container and moved into the new fuel storage vault area for inspection. After completion of inspection, the acceptable new fuel assemblies are lowered by the new fuel elevator for interim storage in the spent fuel racks in the spent fuel pool.

For spent fuel handling, the fuel handling equipment handles the spent fuel assemblies underwater from the time they leave the reactor vessel until they are placed in a container for shipment from the site. Underwater transfer of spent fuel assemblies provides an effective, economic, and transparent radiation shield, as well as a reliable cooling medium for removal of decay heat. The boric acid concentration in the water, as well as spent fuel storage racks that contain neutron shielding materials, is sufficient to preclude criticality. Credit is taken for the boric acid concentration in the spent fuel pool criticality calculations for the normal storage configuration and for fuel handling events.

The associated fuel handling structures may be generally divided into two areas. First, the refueling cavity and fuel transfer canal on the containment side of the fuel transfer tube, flooded only during plant shutdown for refueling. Second, the spent fuel pool and fuel transfer canal on the fuel storage side, kept full of water and always accessible to operating personnel. The fuel storage and containment sides of the fuel transfer canal are connected by a fuel transfer tube fitted with a blind flange on the containment end and a valve on the fuel storage area end. The blind flange is in place except during refueling to ensure containment integrity. Fuel is carried through the tube on an underwater transfer car.

Fuel is moved between the reactor vessel and the FTS by the refueling machine. The FTS moves fuel assemblies between the containment building and the fuel building. After a fuel assembly is placed in the FTS fuel container, the lifting arm pivots the fuel assembly to the horizontal position for passage through the fuel transfer tube. After the transfer car transports the fuel assembly through the transfer tube, the lifting arm at that end of the tube pivots the assembly to a vertical position so that the assembly can be lifted out of the fuel container.

In the fuel building, fuel assemblies are moved about by the spent fuel bridge and hoist. When lifting a fuel assembly, the hoist uses a long-handled tool which ensures that sufficient radiation shielding is maintained. Initially, a shorter tool is used to handle new fuel assemblies, but the new fuel elevator must be used to lower the assembly to a depth at which the bridge and hoist, using the long- handled tool, can move the new fuel assemblies into the fuel storage racks or the FTS.

Decay heat, generated by the spent fuel assemblies in the fuel pool, is removed by the spent fuel pool cooling and purification system. After a sufficient decay period, the spent fuel assemblies may be removed from the fuel racks with the bridge and hoist and loaded into a spent fuel shipping cask for removal from the site.

9.1.4.2.2 Refueling Procedure

Refueling Procedure

Prior to initiating refueling operations, the reactor coolant system

(RCS) is borated and cooled down to refueling shutdown conditions. The following significant points are ensured by the refueling procedure:

1. The refueling water and the reactor coolant contain approximately 2,600 parts per million (ppm) boron. This concentration, together with the negative reactivity of the control rods, is sufficient to keep the core subcritical $k_{eff} \leq 0.95$ during the refueling operations. It is also sufficient to maintain the core subcritical in the unlikely event that all of the rod cluster control assemblies (RCCA) were removed from the core.

2. The water level in the refueling cavity 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 four major phases:

1. Containment Entry

2. Preparation for Fuel Handling

3. Fuel Handling

4. Reactor Assembly

A general description of a typical refueling operation through the phases is given as follows:

Phase I -Containment Entry

The reactor is shut down and cooled to cold shutdown conditions (all rods in). Following a radiation survey, the containment building is entered. At this time, the coolant level in the reactor vessel is lowered to a point slightly below the vessel flange. Then, the fuel transfer equipment and refueling machine are checked for proper operation.

Phase II - Preparation for Fuel Handling

1. Using the auxiliary hook of the polar crane, remove all operating floor shielding plugs from their storage position and place in their refueling orientation.

2. Disconnect the control drive mechanism (CRDM) fan power and instrument cabling.

3. Drain and disconnect the chilled water piping from the CRDM cooling coils. Isolate the reactor head vent piping and drain. Remove accessible part of vessel head vent piping and supports between vessel head and pressurizer cubicle. These pipe lengths may be stored on the CRDM missile shield, or removed and stored in the annulus area. If stored on the missile shield, care must be taken to secure them to the shield, as it is moved during the refueling evolution.

4. Disconnect the CRDM ventilation duct upper elbows. The elbows are stored with brackets hanging from steam generator nitrogen blanket valve catwalk.

5. Disconnect the CRDM ventilation vertical sections and store between steam generators A and D.

6. Move the CRDM missile shield to the north end of the refueling cavity to allow access to the mat access opening.

7. Disconnect the struts connecting the CRDM seismic supports to the refueling cavity liner.

8. Disconnect the CRDM ventilation duct lower sections (pant legs). These sections are stored with brackets hanging from steam generator nitrogen blanket valve catwalk.

9. Remove the nine reactor vessel head insulation sections. Lift over the refueling machine with the polar crane auxiliary hook. Store in the annulus area operating floor.

10. Disconnect and remove the resistance temperature detector (RTD) cabling. Disconnect power and instrument cabling from the reactor vessel head connection and their associated plug boards on the operating floor and secure these cables to the upending cable spreader racks.

11. Tip up the up-ending cable spreading racks to the vertical position and secure with pin on the reactor vessel head lifting assembly.

12. Remove the reactor cavity seal manway protective covers and install the watertight hatches.

13. Remove the checkered plate and support steel over the mat access opening, and store vertically along the steam generator cubicle walls in cubicle A.

14. Using the auxiliary hook, remove the head lifting rig tripod spreader section from the reactor vessel head storage stand and mount on the head lifting rig. Supports for the tripod spreader section storage are removed from the head storage stand.

15. Place new reactor vessel O-rings on the reactor vessel head storage stand.

16. Move the stud tensioners into the reactor cavity using the auxiliary hook of the polar crane. Attach the stud tensioners to the electric hoists on the circumferential rail of the head lifting assembly. Tensioners may be placed on the cavity seal to reduce swing.

17. After the studs have been detensioned (a two-step process), remove the stud tensioners, and mount the three stud spinout devices.

18. The remaining studs are then unthreaded and fitted with their retaining collars. After each stud is removed, a plug is placed in the vacated opening. The guide stud holes are left vacant following the last move to allow placement of the guide studs. These guide studs are stored in the refueling cavity.

19. Remove nine studs (as needed) for alignment pin installation and place in their container. The container is then transferred for stud cleaning.

20. Remove the fuel transfer tube blind flange.

21. Lift the reactor vessel head using the main hook. The head is lifted off the reactor vessel before filling the refueling cavity.

22. Move the reactor vessel head assembly over the mat access opening and lower the head onto the head storage stand. At this location the head is decontaminated, the old 0-rings are removed, and the new 0-rings are installed.

23. Remove the checkered plate and support steel from its storage location and place over the mat access opening.

24. Move the control rod drive missile shield over the mat access opening at the south end of the containment.

25. Using the refueling machine auxiliary hoist, disconnect the CRDM drive shafts, using the CRDM unlatching tool stored on the refueling cavity liner.

26. After testing the rotolock inserts, the internals lifting rig is attached to the upper internals. The upper internals are then lifted on to the upper internals storage stand with the lifting rig. After removing the upper internals, the reactor cavity is filled to the high level setpoint.

The fuel assemblies and RCCAs are now free from obstructions and the core is ready for refueling.

Phase III - Fuel Handling

The refueling sequence is started with the refueling machine. The positions of partially spent assemblies are changed and new assemblies are added to the core. This section represents the normal method of achieving the final re-load core pattern; other methods are also possible.

The general fuel handling sequence for a core off-load and component shuffle in the spent fuel pool is as follows:

1. The refueling machine is positioned over a fuel assembly on the outside row of the core and away from the neutron detectors being used to monitor the core.

2. This fuel assembly with an RCCA, or a thimble plugging device is withdrawn from the core and raised to a predetermined height sufficient to clear the vessel flange and still leave sufficient water covering the fuel assembly.

3. The fuel transfer car is moved into the refueling canal from the fuel storage area.

4. The fuel assembly container is pivoted to the vertical position by the lifting arm.

5. The refueling machine is moved to line up the fuel assembly with the fuel assembly container.

6. The refueling machine loads a fuel assembly into the fuel assembly container of the transfer car.

7. The refueling machine then moves back over the core area for the next fuel assembly. The pattern of removal is designed to remove fuel assemblies containing neutron sources and those fuel assemblies nearest the neutron detectors last.

8. The container is pivoted to the horizontal position by the lifting arm.

9. The fuel container is moved through the fuel transfer tube to the fuel building by the transfer car.

10. The fuel assembly container is pivoted to the vertical position. The fuel assembly is unloaded by the spent fuel handling tool attached to the spent fuel bridge and hoist.

11. The fuel assembly is placed in the spent fuel storage rack.

12. The empty fuel container is pivoted to the horizontal position and moved back into the containment building.

13. The fuel container is pivoted to the vertical position.

14. The refueling machine is ready to transfer the next fuel assembly to the fuel assembly container.

15. This procedure is contained until the core is empty of fuel assemblies.

16. While the fuel is in the spent fuel pool, the RCCA's, neutron sources and thimble plugging devices are shuffled into the correct fuel assemblies for the next operating cycle.

17. The fuel assemblies are then returned to the core in the reverse of this procedure with new fuel replacing the discharge fuel.

Phase IV - Reactor Assembly

Following refueling, reactor assembly is essentially achieved by reversing the operations outlined in Phase II.

During reassembly of the reactor, the vessel head is lowered until the vessel head engages the guide studs. Before reactor vessel head installation, the water is lowered to the top of the reactor vessel flange. This allows visual observation of the insertion of drive rods into their proper locations.

9.1.4.2.3 Fuel Handling for Offsite Shipment

All fuel handling for this evolution is done in the fuel building. The spent fuel shipping cask (SFSC) is brought into the canopy of the fuel building for initial washdown. The lifting yoke for the SFSC is then attached. The lift of the SFSC is made by the 125 ton SFSC trolley. It is taken into the fuel building from the railroad canopy and placed in an upright position in the SFSC washdown sump. At this point, the SFSC is further washed down to preclude as many contaminants as possible from entering into the spent fuel pool. The SFSC head is taken off and stored in the SFSC washdown sump area. After it has been determined that the SFSC has undergone sufficient washdown, it is filled with demineralized water. This is to prevent the SFSC from encountering buoyancy effects when it is being lowered into the cask pit. Prior to the SFSC being put into the cask pit, the gate that is stored on the cask pit wall is moved into place using the spent fuel bridge and hoist.

This serves to prevent the water level in the spent fuel pool from lowering when the cask pit water level is lowered. The cask pit water level is lowered to prevent the SFSC hook and wire rope from being contaminated.

The method of raising and lowering of the SFSC into the cask pit is such that the SFSC cannot undergo more than a 30-foot vertical drop. While moving the cask horizontally, the cask is required to withstand the impact of striking a SSC without radioactive release. Once the SFSC has been lowered to the bottom of the cask pit, the hook and yoke are disconnected and the cask pit is filled to the level of the spent fuel pool. After this has been accomplished, the cask pit gate is placed in its storage position until fuel transfer is complete. Spent fuel is then transferred from storage locations in the spent fuel pool to the SFSC. After the SFSC is filled with spent fuel, the gate is again placed in its position between the cask pit and the spent fuel pool. By using tools provided with the SFSC, the SFSC head is picked up from the SFSC washdown area and placed in the SFSC and tightened down. The cask pit water level is then lowered and the SFSC trolley hook and SFSC yoke are reconnected. The SFSC is then raised out of the cask pit and initially decontaminated by low pressure spray ring and additional water sprays from hoses as it is being pulled out of the cask pit. The SFSC is then taken to the SFSC washdown sump for final decontamination and inspection of the head to ensure it is bolted on properly. Once the SFSC is removed to the washdown sump, the cask pit water level is returned to the same level as the spent fuel pool and the gate is returned to its storage location. After the SFSC has been inspected, it is moved to the railroad canopy for placement on the rail car for removal from the site.

9.1.4.2.4 Component Description

Refueling Machine

The refueling machine (Figure 9.1–9) is a rectilinear bridge and trolley system with a vertical mast extending down into the refueling water. The bridge spans the refueling cavity and runs on rails set into the edge of the refueling cavity. The bridge and trolley motions are used to position the vertical mast over a fuel assembly in the core. A long tube with a pneumatic gripper on the end is lowered down out of the mast to grip the fuel assembly. The tube is long enough so that the upper end is still contained in the mast when the gripper end contacts the fuel. A winch, mounted on the trolley, raises the gripper tube and fuel assembly up into the mast tube. The fuel is transported while inside the mast tube to its new position.

The fuel gripper actuator necessary for the fuel assembly gripper is operated by a cylinder located on the top of the gripper tube.

All controls for the refueling machine are mounted on a console in the trolley. Movement of the machine from one position to another is automatically accomplished by entering the coordinates required. A panel display indicates the position selected. A panel indicator shows when the selected position has been reached. In addition, position indicators show the position of the bridge and trolley at all times. The position indicators receive the position information from the encoders on the bridge and trolley tracks for all 3 standard modes of operation (Auto, Semi-Auto and Manual).

In addition to the automatic controls, completely separate manual controls are provided for nonautomatic operation. Position indication for this mode may be from either the position encoders from the automatic mode or from standard pointers to rail markings.

The maximum speed (approximately) for the bridge is 60 fpm, 40 fpm for the trolley and 40 fpm for the hoist. The auxiliary monorail hoist on the refueling machine has a two-step magnetic controller to give hoisting speeds of approximately 7 and 20 fpm.

Electrical interlocks and limit switches on the bridge and trolley drives prevent damage to the fuel assemblies. The winch is also provided with limit switches which prevent a fuel assembly from being raised above a safe shielding depth. In an emergency, the bridge, trolley, and winch can be operated manually by using a hand-wheel on the motor shaft.

Spent Fuel Bridge and Hoist

The spent fuel bridge and hoist structure (Figure 9.1–10) is a wheel- mounted walkway spanning the spent fuel pool and carries a trolley mounted electric hoist on an overhead structure. This machine is used for handling fuel assemblies within the spent fuel pool, cask pit, and fuel transfer canal by means of a long-handled tool suspended from the hoist. A load monitoring device is attached between the hoist hook and the fuel handling tool for monitoring fuel assembly loads. The hoist travel and tool length are designed to limit the maximum lift of a fuel assembly to a safe shielding depth.

The bridge and hoist speeds are variable. The maximum speed (approximate) for the bridge is 33 fpm and for the hoist is 20 fpm.

The hoist trolley is motor-driven.

New Fuel Elevator

The new fuel elevator (Figure 9.1–11) consists of a box shaped elevator assembly with its top end open and sized to house one fuel assembly. It is used normally to lower a new fuel assembly to the bottom of the fuel storage area where it is transported to the storage racks by the spent fuel bridge and hoist structure.

The new fuel elevator can also be used for installing storage baskets, or new fuel inserts such as control rods, burnable poisons, source assemblies or thimble plugs into new fuel assemblies or a dummy fuel assembly for transfer of components into the fuel pool. The new fuel elevator is also used to store fuel for fuel repair and inspection activities. When the new fuel elevator is used for fuel repair or inspection activities, specific procedures are written to control the raising and lowering of the elevator with spent fuel in the elevator.

Fuel Transfer System

The FTS (Figure 9.1–12) includes an underwater, winch cable driven transfer car that runs on tracks extending from the containment side of the fuel transfer canal, through the transfer tube, and into the fuel building side of the fuel transfer canal; a hydraulically actuated lifting arm is at each end of the transfer tube. The fuel container in the containment side of the fuel transfer canal receives a fuel assembly in the vertical position from the manipulator crane. The fuel assembly is then pivoted to a horizontal position for passage through the transfer tube. After passing through the tube, the fuel container is raised to a vertical position for removal of the fuel assembly by a tool suspended from a hoist mounted on a spent fuel bridge and hoist structure in the fuel building. The spent fuel bridge and hoist structure then moves over a storage position and places the spent fuel assembly in the spent fuel storage racks.

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

Spent Fuel Assembly Handling Tool

The spent fuel assembly handling tool (Figure 9.1–14) is used to handle new and spent fuel assemblies in the spent fuel pool, the cask pit and the fuel transfer canal on the fuel building side. It is a manually actuated tool, suspended from the spent fuel bridge and hoist, which uses four cam-actuated latching fingers to grip the underside of the fuel assembly top nozzle. The operating handle to actuate the fingers is located at the top of the tool. When the fingers are latched, a pin is inserted into the operating handle which prevents the fingers from being accidentally unlatched during fuel handling operations.

New Fuel Assembly Handling Tool

The new fuel assembly handling tool (Figure 9.1–15) is used to lift and transfer fuel assemblies from the new fuel shipping containers to the new fuel dry storage vault, then to the new fuel elevator. A manually actuated tool, suspended from the new fuel handling crane, utilizes four cam-actuated latching fingers to grip the underside of the fuel assembly top nozzle. The operating handles which actuate the fingers are located at the side of the tool. When the fingers are latched, the safety screw is turned in to prevent accidental unlatching of the fingers.

Reactor Vessel Head Lifting Device

The reactor vessel head lifting device consists of a welded and bolted structural steel frame with suitable rigging to enable the crane operator to lift the head and store it during refueling operations. Attached to the head lifting device are the monorail and hoists for the reactor vessel stud tensioners. The lifting device is permanently attached to the reactor vessel head. The vessel head lift rig is attached to the top of the head lifting device. This lift rig is removed and stored during operation.

Reactor Internals Lifting Device

The reactor internals lifting device (Figure 9.1–16) is a structural frame suspended from the polar crane. The frame is lowered onto the guide tube support plate of the internals and is mechanically connected to the support plate by three breech-lock type connectors.

Bushings on the frame engage guide studs in the vessel flange to provide alignment during removal and replacement of the internals package.

A cylindrical radiation flange shield, which weights 39,000 lbs., was attached to the lower portion of the lift rig during the 1993 outage. The shield reduces radiation exposure to personnel working in the area.

Reactor Vessel Stud Tensioner

The stud tensioners (Figure 9.1–17) are used to secure the head closure joint at every refueling. The stud tensioner is a hydraulically operated device that uses oil as the working fluid. The device permits preloading and unloading of the reactor vessel closure studs at refueling conditions. Stud tensioners minimize the time required for the tensioning or unloading operation. Tensioners are installed on preselected reactor vessel studs and applied simultaneously as specified in the reactor vessel stud tensioning/detensioning procedures. A single hydraulic pumping unit operates the tensioners, which are hydraulically connected in series. The studs are tensioned to their operational load in two steps to prevent high stresses in the flange region and unequal loadings in the studs. An unloading device prevents overstroking of the tensioner by diverting hydraulic fluid flow to the reservoir and preventing further piston travel.

New Fuel Receiving Crane

The new fuel receiving crane is a 10-ton overhead bridge crane located in the northeast corner of the fuel building. Its purpose is to remove the new fuel assembly shipping containers from the truck on which they were delivered to either a storage location or a location where the new fuel handling crane has access to the fuel assemblies in the shipping containers.

New Fuel Handling Crane

The new fuel handling crane is a 10 ton overhead bridge crane that is located along the western wall of the fuel building. The crane covers the area over the new fuel elevator in the fuel transfer canal. The purpose of the crane is to remove new fuel assemblies from their shipping containers and transfer them to the new fuel dry storage vault. Once the assemblies are inspected and approved, the new fuel handling crane is used to transport them to the new fuel elevator for interim storage in the spent fuel pool.

Spent Fuel Shipping Cask Trolley

The spent fuel shipping cask trolley is a 125 ton crane used to transfer the spent fuel shipping cask (SFSC) from its delivery point in the railroad canopy of the fuel building through the fuel building to the cask pit. The spent fuel shipping cask trolley (3MHF-CRN1) has been designed to meet the single failure proof requirements. The design features will ensure that a single failure will not result in the loss of the capability of the system to safely retain the load. Load drop events are not credible for loads lifted by the SFSC trolley when handled and rigged in accordance with the single failure criteria. The SFSC trolley design conforms to the following:

NUREG-0554
NUREG-0612
ASME NOG-1
CMAA #70 (Crane Manufacturers Association of America)

The design of the upgraded trolley has considered the possibility of immersion. Therefore, special material and lubrication requirements for the wire rope and load block components (i.e., sheave and thrust bearings) will insure compatibility with the fuel pool chemistry as well as provisions for drain holes in the enclosed portion of the lower block to allow for gravity drainage. The trolley design will limit the potential of foreign material to enter the fuel pool. This includes adequate measures to prevent lubricants and hydraulic fluids from leaking into the fuel pool.

Auxiliary Hoist

The 5 ton auxiliary crane, which includes the auxiliary hoist, trolley and bridge and related components, is of commercial grade design and construction. This auxiliary crane is not designed to single failure proof criteria and will not be required to lift critical loads in safety related areas.

Crane Control

The SFSC trolley and auxiliary hoist will utilize a remote control radio transmitter for operation. All emergency functions, hoisting and trolley motions will be controlled by the remote radio controller. An operators console is provided on the crane plateform, which has emergency functions, hoisting, and trolley motions and can be used for emergency or backup operation.

Containment Structure Polar Crane

The containment structure polar crane consists of two 200 ton main hoists and one 30 ton auxiliary hoist. The crane is used to remove and reinstall the upper reactor internals, reactor head, and attachments.

9.1.4.2.5 Applicable Design Codes

The design codes and standards used for the FHS are given in Sections 3.2 and 9.1.4.3.

Other design codes and standards used are:

American National Standards Institute - Standard Safety Code for Overhead and Gantry Cranes (B30.2.0) Specification of General Requirements for a Quality Program (Z1.8)

American Welding Society - Structural Welding Code (D1.1)

National Electrical Manufacturers Association - Applicable Standards

Steel Structures Painting Council - Near White Blast Cleaning (Standard SP-10) Shop, Field, and Maintenance Painting (Standard PA1)

Code of Federal Regulations, Title 10, Part 50 Appendix B - Quality Assurance Criteria for Nuclear Power Plants

9.1.4.3 Safety Evaluation

9.1.4.3.1 Safe Handling

Design criteria for the FHS are as follows:

1. The primary design requirement of the FHS equipment is reliability. A conservative design approach is used for all load bearing parts. Where possible, components are used that have a proven record of reliable service. Throughout the design process, consideration is given to the fact that the equipment spends long idle periods stored in an atmosphere of 120°F and high humidity.

2. Except as otherwise specified, the refueling machine and spent fuel bridge and hoist structure are designed and constructed in accordance with Crane Manufacturers Association of America, Inc. (CMAA) Specification 70 for Class A-1 service.

3. The static design load for the crane structures and all lifting components is normal dead and live loads plus three times the fuel assembly weight with an RCCA.

4. The allowable stresses for the refueling machine and spent fuel bridge and hoist structure supporting the weight of a fuel assembly are as specified in the ASME B&PV Code Section III, Appendix XVII-2200.

5. The design load on the wire rope hoisting cables does not exceed 0.20 times the average breaking strength. Two independent cables are used, and each is assumed to carry one half the load.

6. Critical components and other parts which operate above the reactor are designed with vibration resistant fastening systems.

Industrial codes and standards used in the design of the fuel handling equipment are as follows:

1. The refueling machine and spent fuel bridge and hoist: Applicable sections of CMAA Specification No. 70.

2. Structural equipment: ASME B&PV Code, Section III, Appendix XVII, Subarticle 2200.

3. Fuel Transfer Tube: ASME Code, Section III, Class MC.

4. Electrical equipment: Applicable standards and requirements of the National Electric Code, and NFPA 70 for design, installation, and manufacturing.

5. Materials: Main load-bearing materials conform to the specifications of the ASTM standards.

6. Safety: OSHA standards, 20 CFR Parts 1910 and 1926, including load testing requirements, the requirements of ANSI N18.2, NRC Regulatory Guide 1.29, and GDC 61 and 62.

<u>Refueling Machine</u>

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

1. Safety Interlocks - Operations which could endanger the operator or damage the fuel are prevented by mechanical or fail-safe electrical interlocks, or by redundant electrical interlocks. All other interlocks are intended to provide equipment protection and may be implemented either mechanically or by electrical interlock, not necessarily fail-safe.

   Fail-safe electrical design of a control system interlock may be applied according to the following rules.

   a. Fail-safe operation of an electrically operated brake is such that the brake engages on loss of power.

   b. Fail-safe operation of an electrically operated clutch is such that the clutch engages on loss of power. The Millstone Unit 3 design does not utilize an electric clutch.

   c. Fail-safe operation of a relay is such that the de-energized state of the relay prevents unsafe operation.

d. Fail-safe operation of a switch, termination, or wire is such that breakage or high resistance of the circuit prevents unsafe operation.

Those parts of a control system interlock required to be fail-safe which are not or cannot be operated in a fail-safe mode as defined in these rules, are supplemented by a redundant component, or components, to provide the requisite protection:

a. When the gripper is loaded, the crane will not be allowed to traverse unless the guide tube is in the fully retracted position.

b. When the gripper is unloaded and extended from the stationary mast, the crane will not be allowed to traverse.

c. Vertical motion, extending outside of the stationary mast, of the guide tube is permitted only in a controlled area over the reactor, the fuel transfer system and the test fixture.

d. Bridge and trolley travel is limited to a controlled area over the reactor and the fuel transfer system.

e. A key-operated Programmable Logic Controller (PLC) bypass switch is provided to manually defeat system interlocks under administrative controls.

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

g. The loaded fuel gripper does not release unless it is in its down position in the core or in the fuel transfer system, and the weight of the fuel assembly is off the mast load monitor.

h. 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.

i. Raising of the guide tube is not permitted if the hoist loading exceeds the allowable limit set in accordance with the Westinghouse Specification F-5 “Instructions, Precautions, and Limitations for Handling New and Partially Spent Fuel Assemblies.”

j. Lowering of the guide tube is not permitted if slack cable exists in the hoist.

k. The guide is prevented from rising to a height where there is less than 10 feet 6 inches of nominal water coverage over the fuel.

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

m. The guide tube travels only at a controlled speed of about 3 feet per minute when the bottom of the fuel begins to enter the core and the gripper approaches the top of the core. In addition, just above these points, the guide tube automatically stops lowering, and requires acknowledgment from the operator before proceeding.

n. In the transfer machine zone, the fuel transfer system container is prevented from upending unless the loaded gripper is in the full up position, or the unloaded gripper is not extended from the stationary 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. In addition, the fuel transfer system provides an interlock to prevent any vertical moves on the refueling machine until the fuel transfer container is in a vertical position.

2. Bridge and Trolley Hold-Down Devices - Both the refueling machine bridge and trolley are 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 head. Both horizontal and vertical restraints are adequately designed to withstand the forces and overturning moments resulting from the safe shutdown earthquake.

3. 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 to 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 overhaul the hoist. It is necessary to apply torque from the motor to raise or lower the load. In raising, this motor drives a cam to open the brake; 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.

4. Fuel Assembly Support System - The main hoist system is supplied with redundant paths of load support such that failure of any one component does not result in free fall of the fuel assembly. Two wire ropes are anchored to the winch drum and carried to a load equalizing mechanism on the top of the gripper tube.

The working load of fuel assembly plus gripper is approximately 3,000 pounds.

The gripper has four fingers gripping the fuel, any two of which supports the fuel assembly weight.

During each refueling outage and prior to removing fuel, the gripper and hoist system are routinely load tested.

<u>Fuel Transfer System</u>

The following safety features are provided for in the FTS:

1. Traverse Control Interlocks - The control consoles for the Fuel Transfer System (FTS) are located in both the Containment and the Fuel Building.

   In the manual operating mode, the traverse operation is possible only when both lifting arms are in the down position as indicated by the proximity switches. The basic interlock functions are provided by the proximity switches that sense upender position. The hydraulic power unit (HPU) control valve circuit provides a backup interlock. The control logic will inhibit traverse operation if the HPU control valve is energized for the frame up condition. An additional backup interlock is a mechanical latch device that prevents cart motion when the fuel container is not horizontal.

   In the auto sequence mode, the Refueling Machine or Fuel Handling Machine operator can start the traverse operation. In this mode, the fuel container automatically lowers the upender to the down position, the fuel container traverses to the other side and is upended to the vertical condition. Therefore, the interlock can withstand a single failure.

2. Lifting Arm, Transfer Car Position - Two redundant interlocks allow lifting arm operation only when the transfer car is at one end of its travel and, therefore, can withstand a single failure.

   Of these two redundant interlocks, one interlock is a position limit switch in the control circuit. The electronic encoder positioning system also provides a signal of Transfer Car position.

3. Transfer Car, Valve Open - A limit switch on the transfer tube valve provides indication that the valve is open. The valve is also administratively controlled beacuse it is a hand operated valve; i.e., a handwheel is utilized. After opening the valve, the operator is required to secure the handwheel. These dual controls assure the system can withstand a single failure.

4. 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 while 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 in the horizontal position.

5. Lifting Arm, Refueling Machine - The containment side lifting arm is interlocked with the Refueling Machine. The electronic control systems of the Refueling Machine (RM) and the Fuel Transfer System (FTS) are networked. This allows communication between the electronic controls so that if a fuel assembly is present in the Refueling Machine, the load cell in the refueling mast acknowledges this and the FTS uses this information. If there is no load on the mast, and the RM is located over the FTS fuel container, the FTS upender is permitted to operate if the RM mast is retracted into the stationary mast at the gripper weight only (GWO) position. If there is a load indicated on the RM mast, the mast must be at the full-up position.

6. Lifting Arm, Spent Fuel Building Hoist - On the spent fuel pool side, the lifting arm is interlocked with the bridge and hoist. The lifting arm will not operate if the bridge and hoist is over the lifting arm area unless the hoist is at the upper travel limit.

<u>Spent Fuel Bridge and Hoist</u>

The spent fuel bridge and hoist structure includes the following safety features.

1. The spent fuel bridge and hoist controls are interlocked to prevent simultaneous operation of bridge drive and hoist.

2. Bridge drive operation is prevented except when the hoist is in the full up position.

3. An overload protection device is included on the hoist to limit the uplift force which could be applied to the fuel storage racks. The protection device limits the hoist load to the allowable limit set in accordance with the Westinghouse Specification F-5, “Instructions, Precautions, and Limitations for Handling New and Partially Spent Fuel Assemblies.” This overload protection device can be bypassed with a key for special lifts.

4. The static design load on the hoist is the combined dry weight of one fuel assembly and RCCA (1,600 lb) and the weight of the tool (400 lb) which gives it a total weight of approximately 2,000 pounds.

5. Restraining bars are provided on each truck to prevent the bridge from overturning.

6. Brackets are attached to the lower girder to provide supplemental rigging of spent fuel pool gates to prevent a gate from toppling onto spent fuel racks during a

postulated gate drop accident. This prevents potential restriction of fuel storage cell coolant flow, which could potentially overheat stored fuel. The supplemental rigging design consists of a removable wire rope which connects the bracket to a lug attached to the fuel pool gate. The supplemental rigging is employed when a gate is moved in the close vicinity of the spent fuel pool such that the gate could topple onto spent fuel racks during a postulated drop accident. There are two brackets, one for each spent fuel pool gate.

Fuel Handling Tools and Equipment

All fuel handling tools and equipment handled over an open reactor vessel are designed to prevent inadvertent decoupling from crane hooks (i.e., lifting rigs are pinned to the crane hook, and safety latches are provided on hooks supporting tools).

Tools required for handling internal reactor components are designed with fail-safe features that prevent disengagement of the component in the event of operating mechanism malfunction. These safety features apply to the following tools:

1. Control Rod Drive Shaft Unlatching Tool - The air cylinders actuating the gripper mechanism are equipped with backup springs which close the gripper in the event of loss of air to the cylinder. Air-operated valves are equipped with safety locking rings to prevent inadvertent actuation.

2. Spent Fuel Handling Tool - When the fingers are latched, a pin is inserted into the operating handle and prevents inadvertent actuation. The tools weighs approximately 400 pounds and is preoperationally tested at 125 percent the weight of one fuel assembly and RCCA (1600 lb).

3. New Fuel Assembly Handling Tool - When the fingers are latched, a safety screw is inserted in, preventing inadvertent actuations. The tool weighs approximately 100 pounds and is preoperationally tested at 125 percent the weight of one fuel assembly and RCCA (1,600 lb).

9.1.4.3.2 Seismic Considerations

The safety classifications for all fuel handling and storage equipment are listed in Section 3.2. These safety classes provide criteria for the seismic design of the various components. Safety Class 1 and 2 equipment are designed to withstand the forces of the OBE and SSE. For normal conditions plus OBE loadings, the resulting stresses are limited to allowable working stresses as defined in the ASME B&PV Code, Section III, Appendix XVII, for normal and upset conditions. For normal conditions plus SSE loadings, the stresses are limited to within the allowable values given by Subarticle NA 2110 for critical parts of the equipment which are required to maintain the capability of the equipment to perform its safety function. Permanent deformation is allowed for the loading combination which includes the SSE to the extent that there is no loss of any safety function.

The Safety Class 3 fuel handling and storage equipment satisfies the Safety Class 1 and 2 criteria for the SSE. Consideration is given to the OBE only insofar as failure of the Safety Class 3 equipment might adversely affect Safety Class 1 or 2 equipment.

For nonnuclear safety equipment, design for the SSE is included if failure might adversely affect a Safety Class 1, 2, or 3 component. Design for the OBE is considered if failure of the nonnuclear safety component might adversely affect a Safety Class 1 or 2 component.

9.1.4.3.3 Containment Pressure Boundary Integrity

The fuel transfer tube which connects the refueling cavity (inside the reactor containment) and the fuel transfer canal (outside the containment) is closed on the refueling cavity side by a blind flange at all times except during refueling operations. Two seals are located around the periphery of the blind flange with leak-check provisions between them.

9.1.4.3.4 Radiation Shielding

During all phases of spent fuel transfer, the design dose rate from the spent fuel at the surface of the water is 2.5 mrem/hr or less. This is accomplished by maintaining a minimum of 10 feet 6 inches of water above the active fuel during fuel transit operations.

The two fuel handling devices used to raise and lower spent fuel assemblies are the refueling machine and the spent fuel bridge and hoist. The refueling machine uses an electrical limit switch which stops upward motion of the guide tube to assure that active fuel is more than 10 feet 6 inches from the normal water level in the refueling cavity. The spent fuel bridge and hoist moves spent fuel with a long-handled tool. The hoist motor geared limit switch stops upward motion of the hoist to maintain a minimum of 10 feet 6 inches of water from the active fuel to the normal water level in the spent fuel pool.

Fuel repair and inspection activities may cause portions of irradiated fuel assemblies to be raised to less than 10 feet 6 inches from the surface of the water. When fuel repair and inspection is done, specific procedures are written to control the repair or inspection activity and maintain radiation doses at the surface of the pool at level consistent with safe ALARA practices.

9.1.4.4 Inspections and Testing Requirements

Administrative controls contained in Project, Operating, Surveillance, and Maintenance Procedures have been established to provide test and inspection requirements for equipment associated with the fuel handling system.

9.1.4.5 Instrumentation Requirements

The control systems for the refueling and fuel handling machines and FTS are discussed in Section 9.1.4.3.1. A discussion of additional electrical controls, such as the interlocks and main hoist braking system for the FHS, are discussed in Section 9.1.4.3.1.

9.1.5 OVERHEAD HEAVY LOAD HANDLING SYSTEMS

In response to NUREG-0612, Millstone Nuclear Power Station, Unit No. 3 submitted a report to the NRC titled ‘NUREG-0612, Control of Heavy Loads,’ dated March 14, 1985. In the report, Millstone Unit 3 committed to the principle of NUREG-0612, including an operator training program, periodic inspection and maintenance program for the cranes and identification of safe load paths for loads that meet the NUREG-0612 criteria for a heavy load, (for the purpose of this review conservatively considered to be 1800 lbs. and greater). Volumetric examinations using Acoustic Emissions techniques may be used solely, or in conjunction with the conventional surface examinations recommended by NUREG-0612/ANSI N14.6-1978, to verify the continuing compliance of the specially designed lift rigs, for the Reactor Head and the Reactor Internals.

NRC Bulletin 96-02, ‘Movement of Heavy Loads Over Spent Fuel, Over Fuel in the Reactor Core, or Over Safety Related Equipment,’ required utilities to review regulatory guidelines associated with the control and handling of heavy loads over spent fuel, over fuel in the reactor core, or over safety-related equipment while the unit is at power, (in all modes other than cold shutdown, refueling and defueled). Administrative procedures have been established to guide the operator in determining whether a NUREG-0612 type lift exists. Consistent with the 10 CFR 50.59 revision effective 7/2001, should a NUREG-0612 lift be contemplated that has not been previously evaluated, the lift will be evaluated using the appropriate station change process.

9.1.6 REFERENCES FOR SECTION 9.1

9.1-1 NEI 16-03-A, Revision 0, “Guidance for Monitoring of Fixed Neutron Absorbers in Spent Fuel Pools,” May 2017.

9.1-2 Letter from R. Guzman (NRC) to D. Stoddard (Dominion Energy), “Millstone Power Station, Unit No. 3 - Issuance of Amendment No. 273 Regarding Technical Specification Changes for Spent Fuel Storage and New Fuel Storage (EPID L-2018-LLA-0126), dated May 28, 2019.

TABLE 9.1–1 FUEL POOL COOLING AND PURIFICATION SYSTEM PRINCIPAL COMPONENT DESIGN CHARACTERISTICS

Fuel Pool Cooling Pumps	
Quantity	2
Capacity (gpm)	3,500
Head (feet)	115
Design pressure (psig)	200
Design temperature (°F)	200
Fuel Pool Heat Exchangers	
Quantity	2
Design heat load per exchanger (Btu/hr)	27.7×10^6
Reactor plant component cooling water flow per exchanger (gpm)	1,800
Reactor plant component cooling water inlet temperature (°F)	95
Reactor plant component cooling water outlet temperature (°F)	126
Fuel pool cooling flow (gpm)	3,500
Fuel pool water inlet temperature (max °F)	150
Fuel pool water outlet temperature (max °F)	125
Tube Side design pressure (psig)	150
Design temperature (°F)	200
Fuel Pool Purification Pumps	
Quantity	2
Capacity (gpm)	250
Head (feet)	277.6
Design pressure (psig)	200
Design temperature (°F)	200
Fuel Pool Prefilters	
Quantity	2
Capacity (gpm) Design pressure (psig)	300 165
Design temperature (°F)	200
Fuel Pool Demineralizer	

TABLE 9.1–1 FUEL POOL COOLING AND PURIFICATION SYSTEM PRINCIPAL COMPONENT DESIGN CHARACTERISTICS (CONTINUED)

Quantity	1
Capacity (gpm)	150
Design pressure (psig)	165
Design temperature (°F)	200
Fuel Pool Postfilter	
Quantity	1
Capacity (gpm)	300
Design pressure (psig)	165
Design temperature (°F)	200
Fuel Pool Coarse Filter	
Quantity	1
Capacity (gpm)	300
Design pressure (psig)	165
Design temperature (°F)	200

TABLE 9.1–2 PERFORMANCE CHARACTERISTICS OF THE FUEL POOL COOLING SYSTEM (ONE FUEL POOL COOLER OPERATING)

Operating Condition	Full Core Offload	Emergency Full-Core Off-load	Normal Plant Operation
Heat Load BTU/hr	95°F CCP 36.08×10^6	Bounded by Full Core Offload	21.1×10^6
	90°F CCP 39.19×10^6		
	85°F CCP 42.30×10^6		
	80°F CCP 45.41×10^6		
Required Duty of One Fuel Pool Cooler BTU/hr	95°F CCP 34.20×10^6	Bounded by Full Core Offload	20.37×10^6
	90°F CCP 37.31×10^6		
	85°F CCP 40.42×10^6		
	80°F CCP 43.53×10^6		
Heat Removal by Evaporation BTU/hr	1.88×10^6	1.88×10^6	0.73×10^6
Maximum Temperature Long Term	150°F	150°F	127.6°F
Maximum Peak Temperature Short Term	155.7°F	Bounded by Full Core Offload	N/A
Maximum Peak Temperature (Accidents)	200°F in 4.41 hours (Condition is outside Design Basis)	Bounded by Full Core Offload	148.8°F - Following a DBA with a four hour loss of pool cooling
Design Limits	Maximum Long Term Temperature (Structural Requirement):		150°F
	Maximum Short Term Temperature (Structural Requirement):		200°F
	Maximum Temperature Loss of Pool Cooling:		200°F

TABLE 9.1–2 PERFORMANCE CHARACTERISTICS OF THE FUEL POOL COOLING SYSTEM (ONE FUEL POOL COOLER OPERATING) (CONTINUED)

Operating Condition	Full Core Offload	Emergency Full-Core Off-load	Normal Plant Operation
Flow Rates	Tube Side - Fuel Pool Water (SFC):		3,500 gpm
	Shell Side - Reactor Plant Component Cooling Water CCP):		1,800 gpm
Cooling Water Temperatures	Reactor Plant Component Cooling (CCP) (Design):		95°F
	Service Water Temperature (Cools CCP) (Design):		80°F

FIGURE 9.1–1 PICTORIAL VIEW OF TYPICAL REGION 3 RACK MODULE

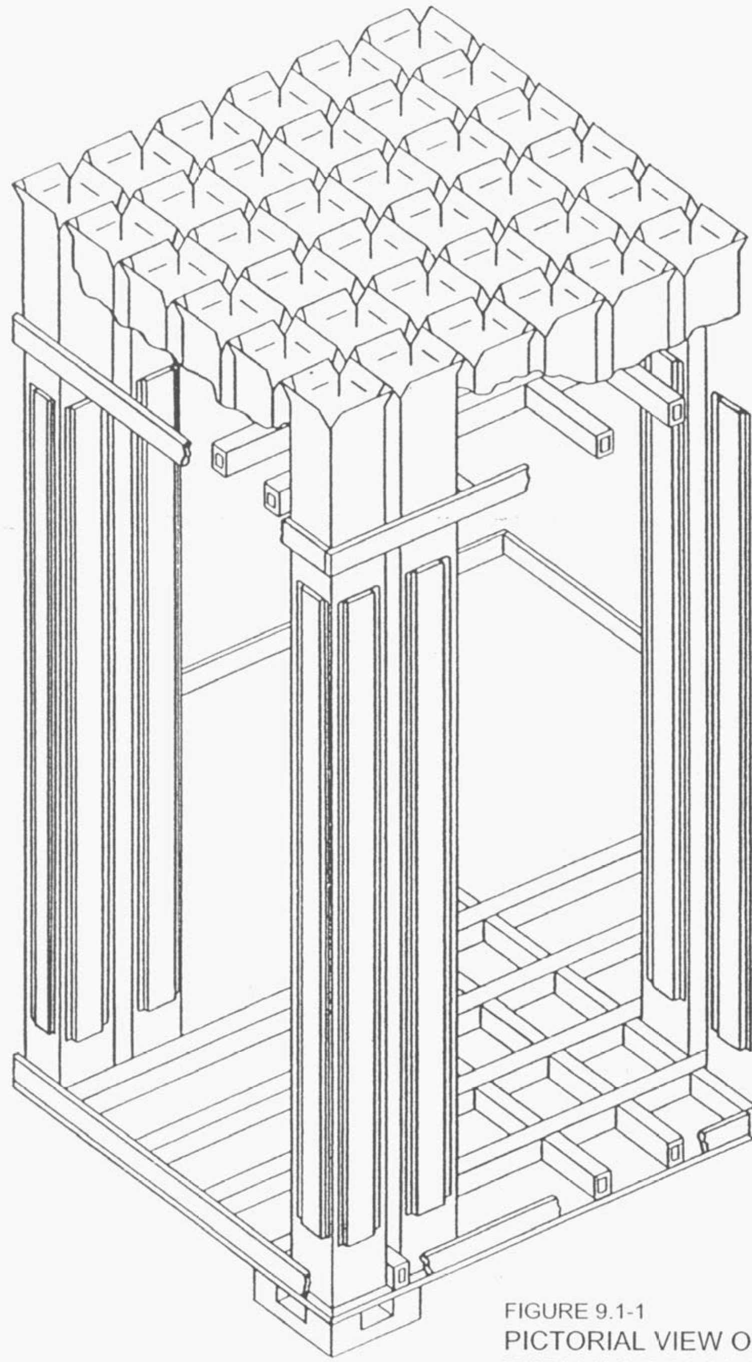


FIGURE 9.1-1
PICTORIAL VIEW OF TYPICAL
REGION 3 RACK MODULE
MILLSTONE NUCLEAR POWER STATION
UNIT 3
FINAL SAFETY ANALYSIS REPORT

October 2000 (98-116)

FIGURE 9.1–2 TOP VIEW OF 6X6 RACK ARRAY (REGION 3)

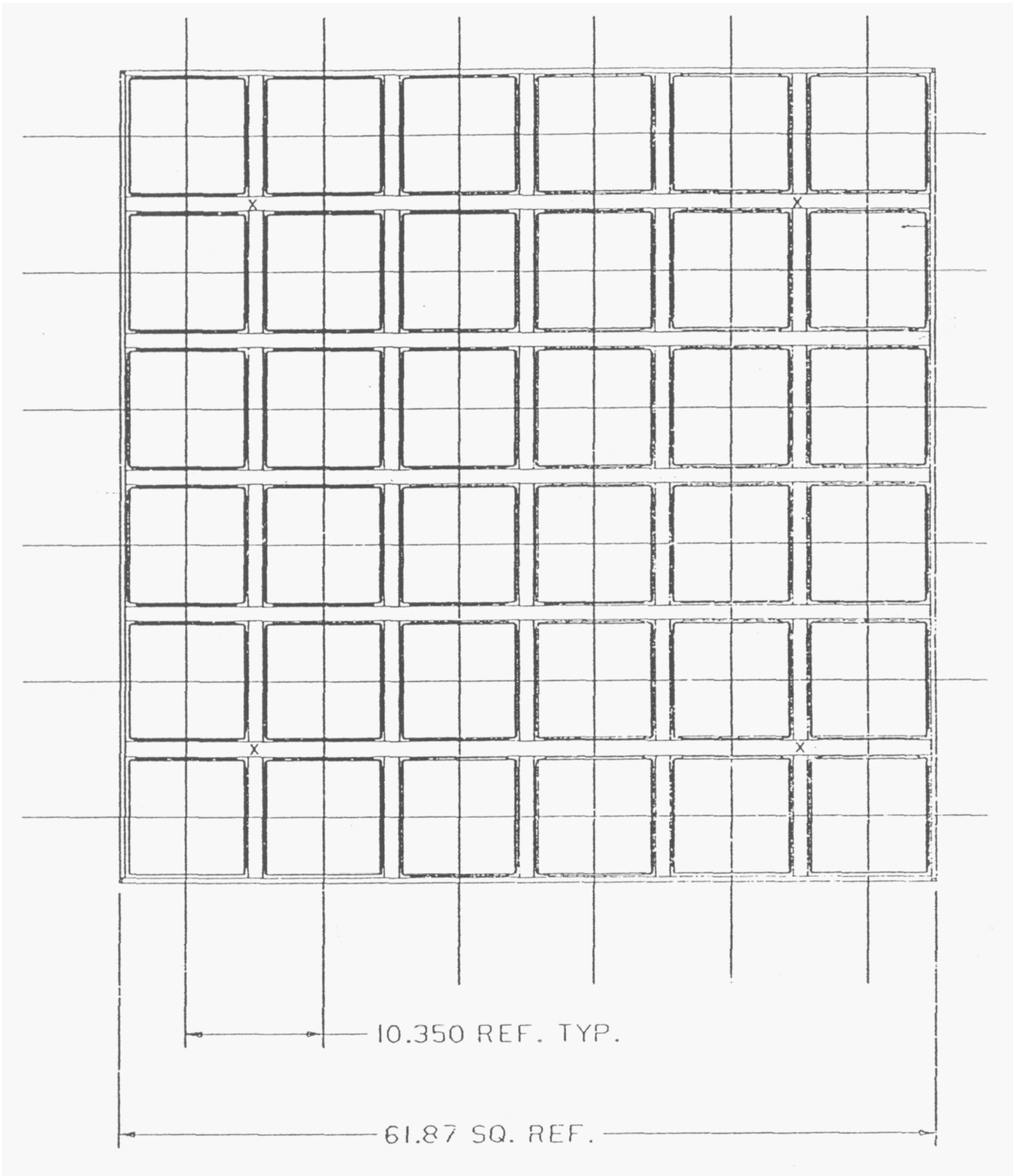


FIGURE 9.1–2A DELETED BY PKG FSC 98-MP3-116

FIGURE 9.1–3 SIDE VIEW OF 6X6 RACK ARRAY (REGION 3)

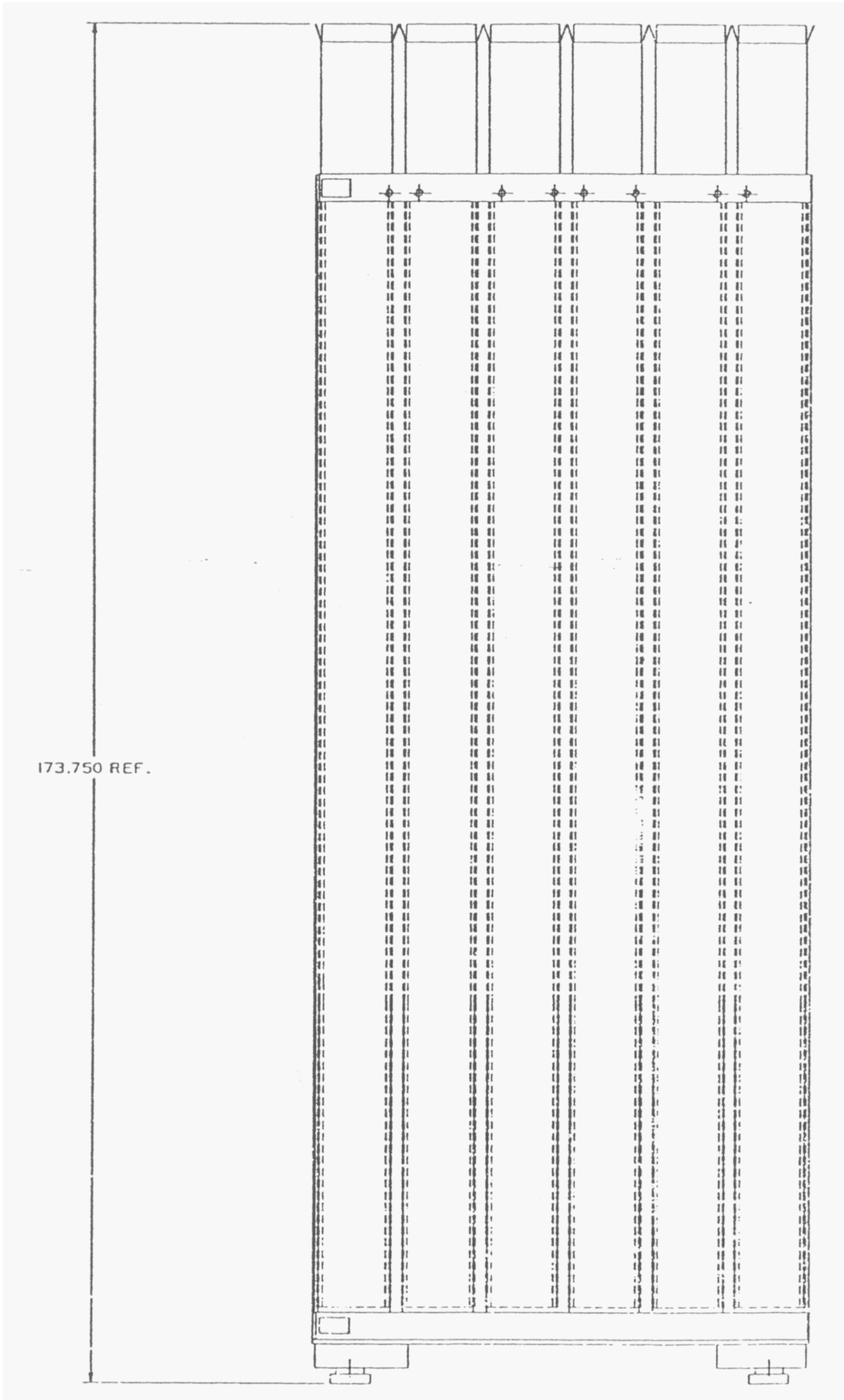


FIGURE 9.1–4 NOT USED

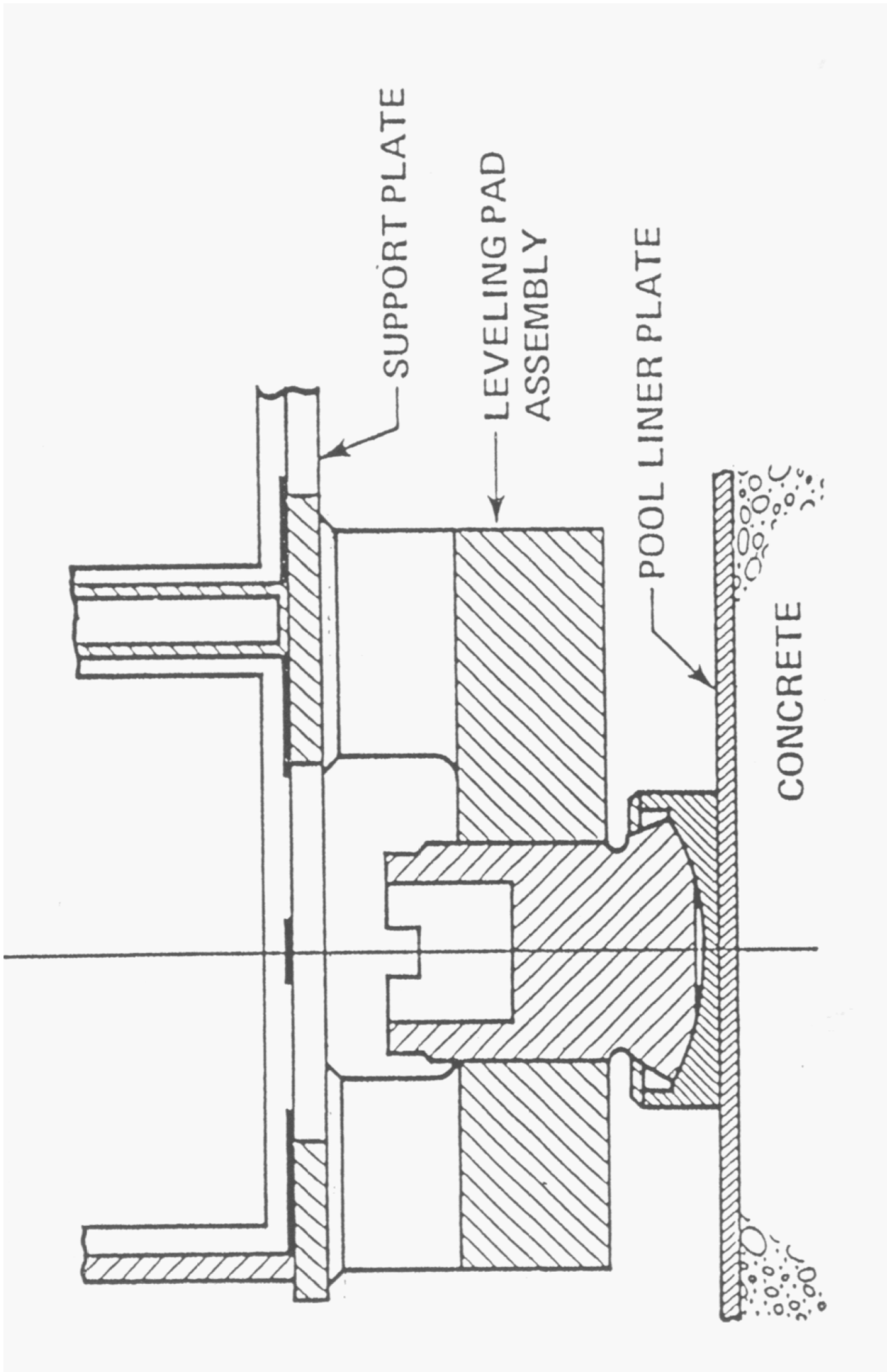


FIGURE 9.1–5 ADJUSTABLE FUEL RACK LEVELING PAD (REGION 3)

FIGURE 9.1–6 P&ID FUEL POOL COOLING AND PURIFICATION SYSTEM

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.1–7 BULK POOL TRANSIENT TEMPERATURE PLOT (FULL CORE OFFLOAD)

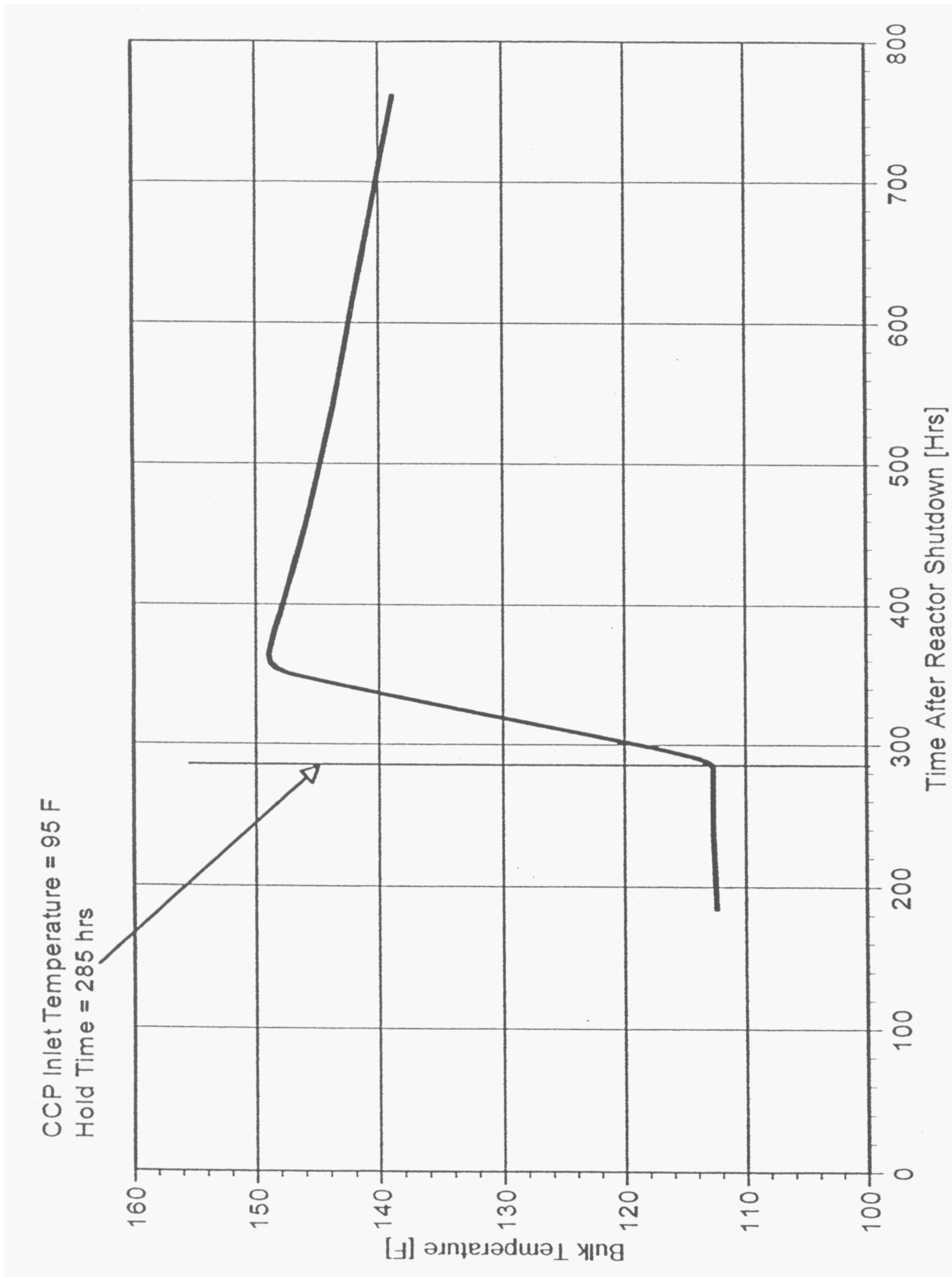


FIGURE 9.1–7A BULK POOL TRANSIENT TEMPERATURE PLOT (EMERGENCY CORE OFFLOAD)

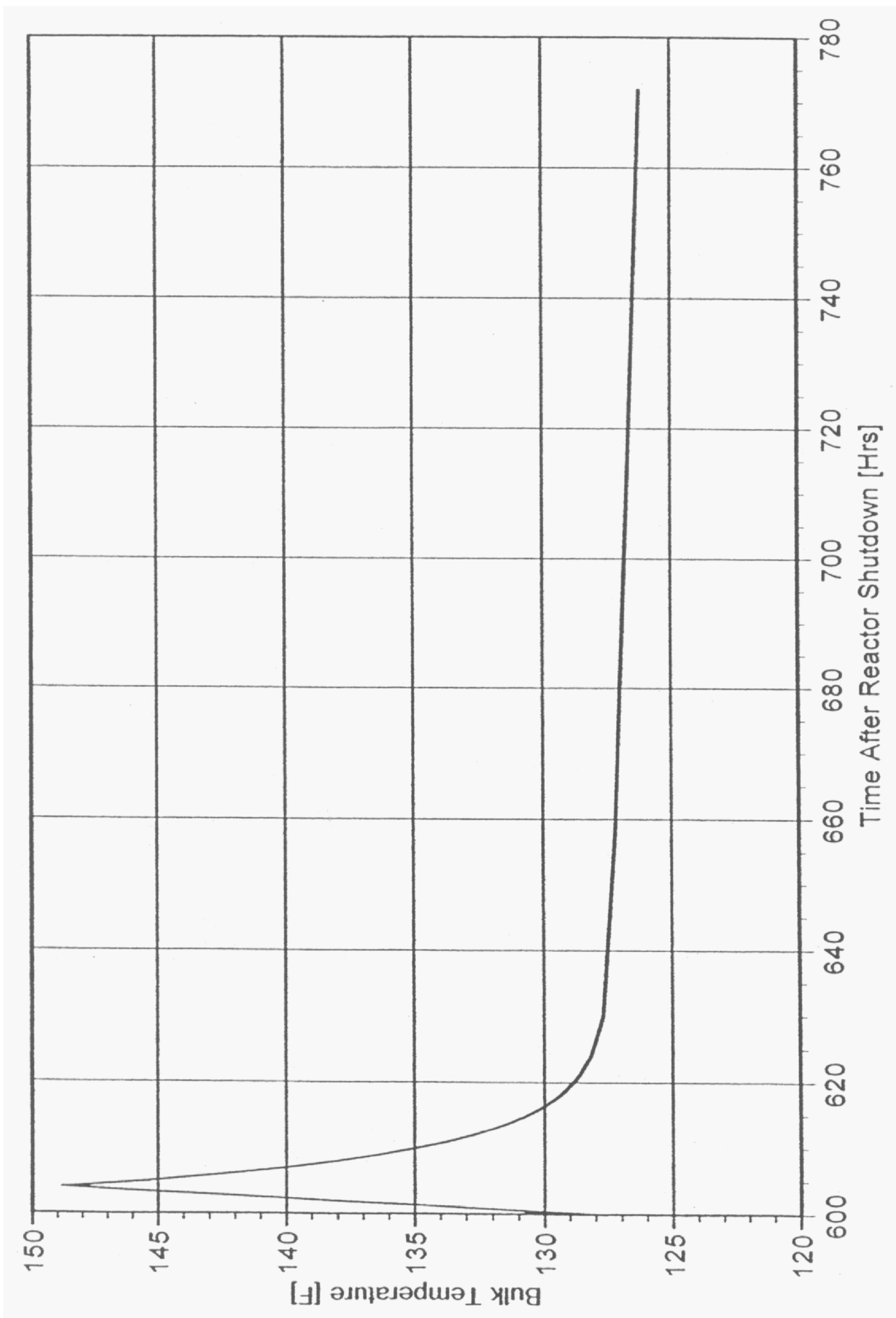


FIGURE 9.1–8 COOLDOWN CURVE FOR NORMAL OPERATION (4 HOURS LOSS OF POOL COOLING)

FIGURE 9.1–9 REFUELING MACHINE

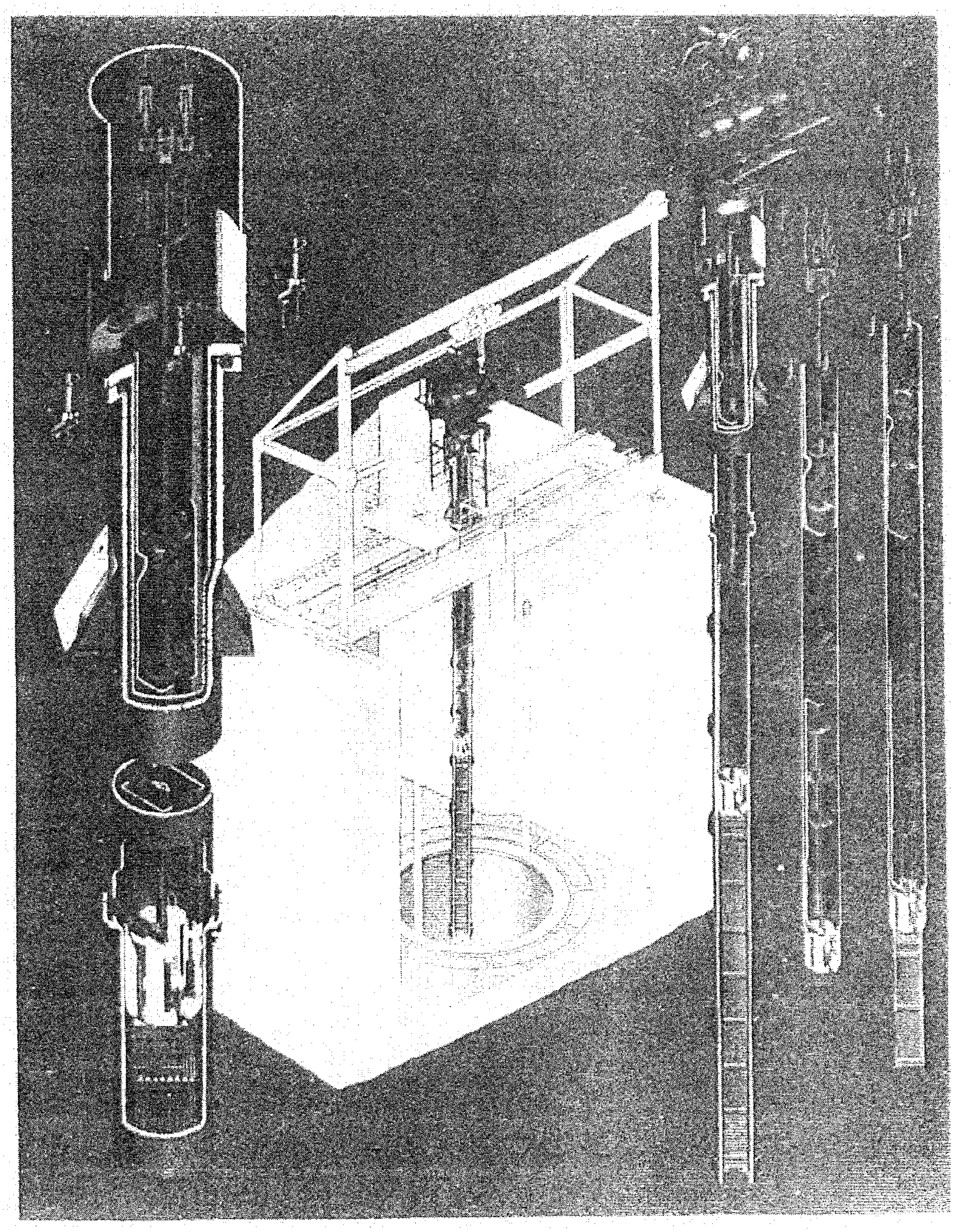


FIGURE 9.1–10 SPENT FUEL BRIDGE AND HOISTING STRUCTURE

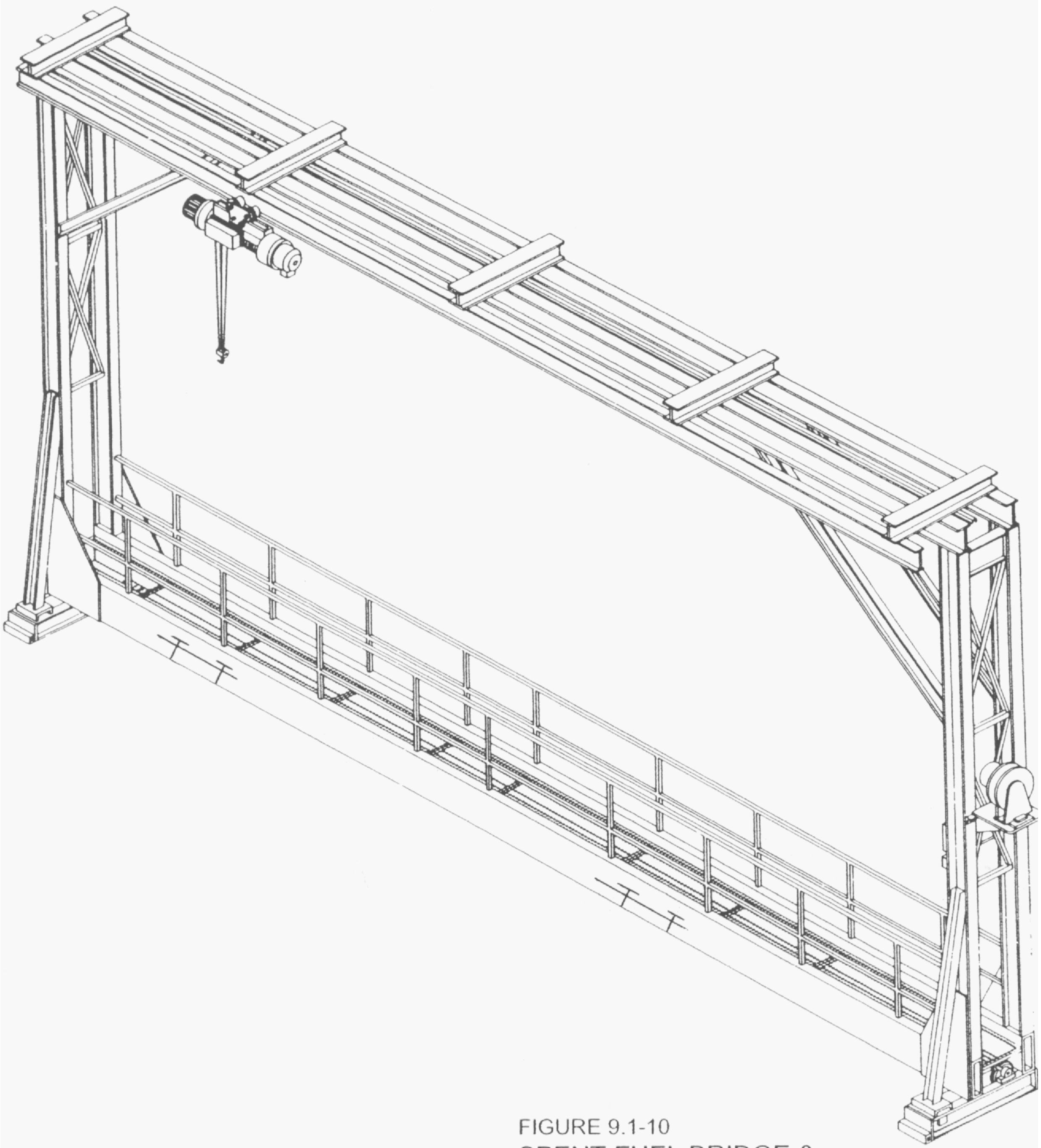


FIGURE 9.1-10
SPENT FUEL BRIDGE &
HOISTING STRUCTURE
(NOT TO SCALE)

FIGURE 9.1–11 NEW FUEL ELEVATOR

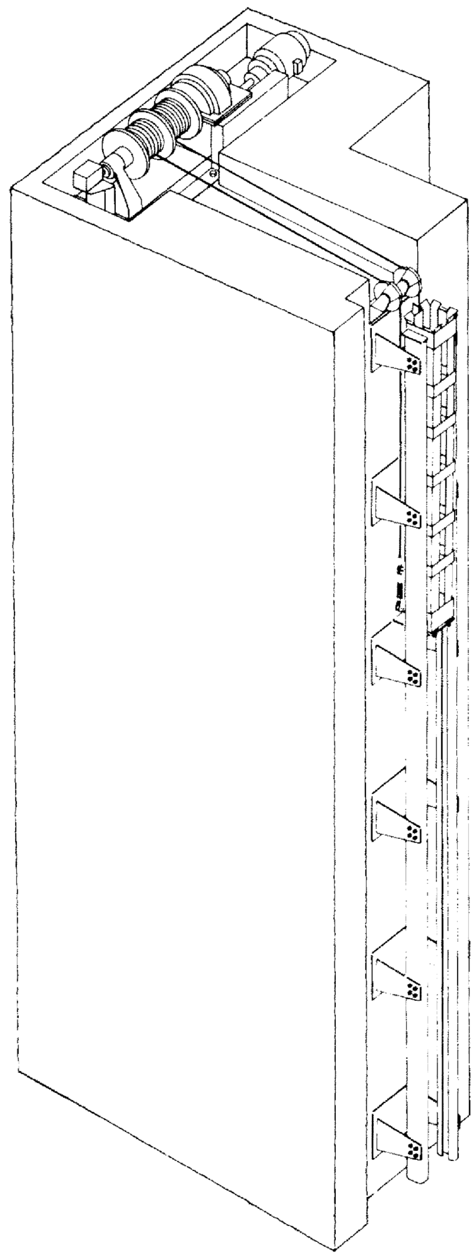


FIGURE 9.1–12 FUEL TRANSFER SYSTEM

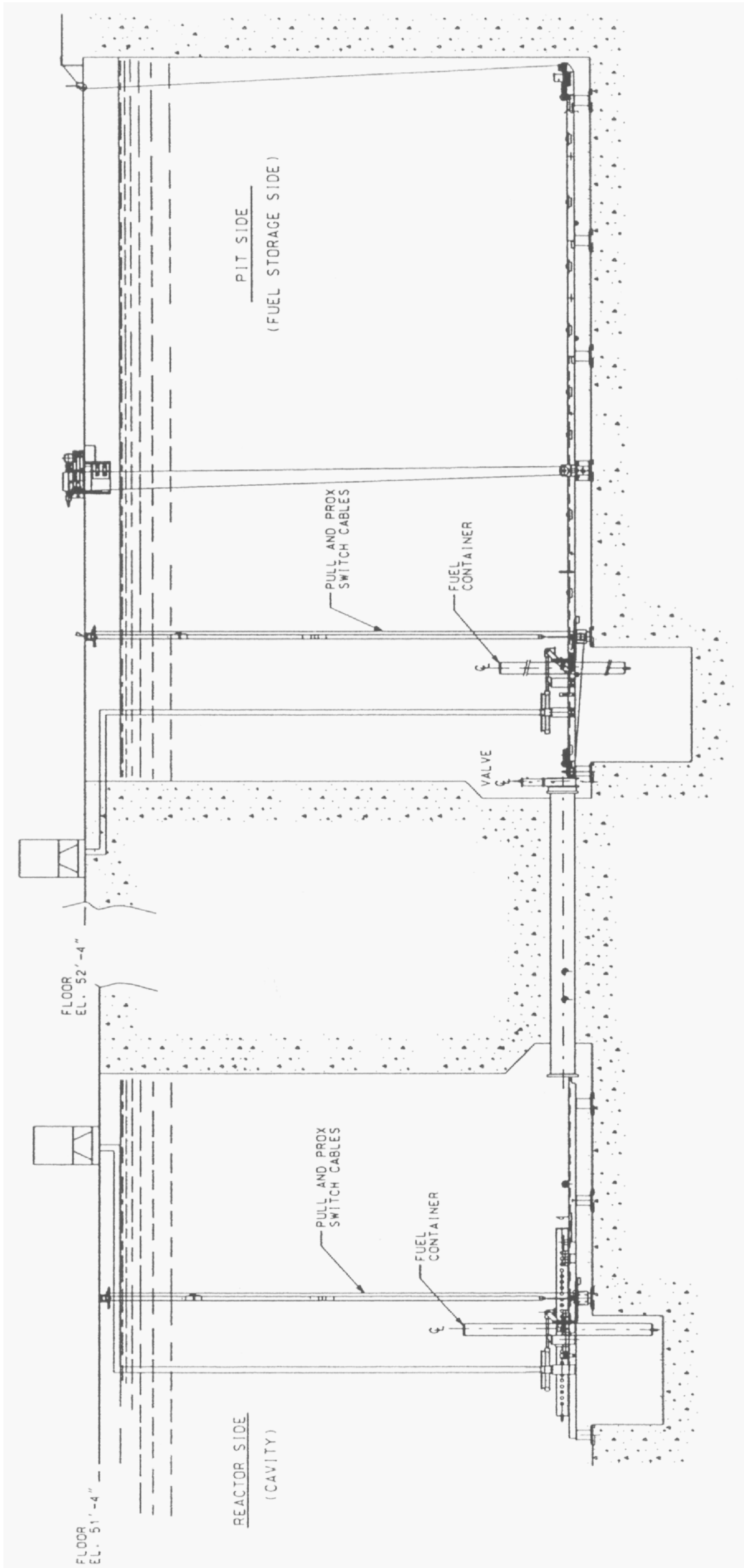


FIGURE 9.1–13 DELETED BY PKG FSC 00-MP3-045

FIGURE 9.1–14 SPENT FUEL HANDLING TOOL

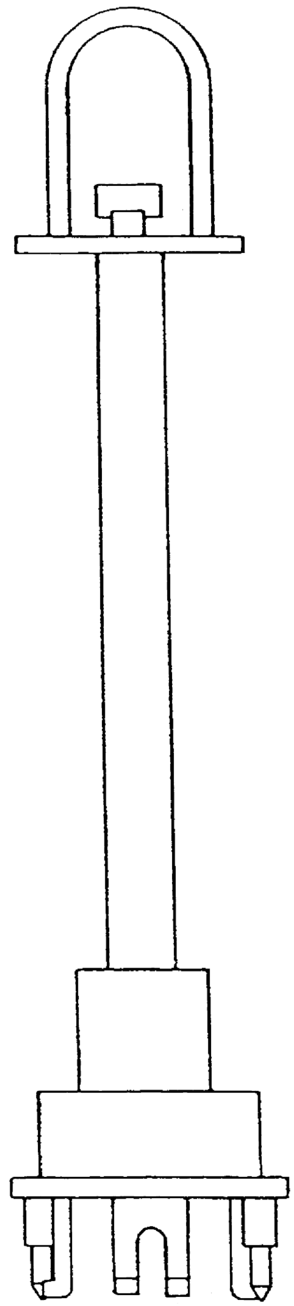


FIGURE 9.1–15 NEW FUEL HANDLING TOOL

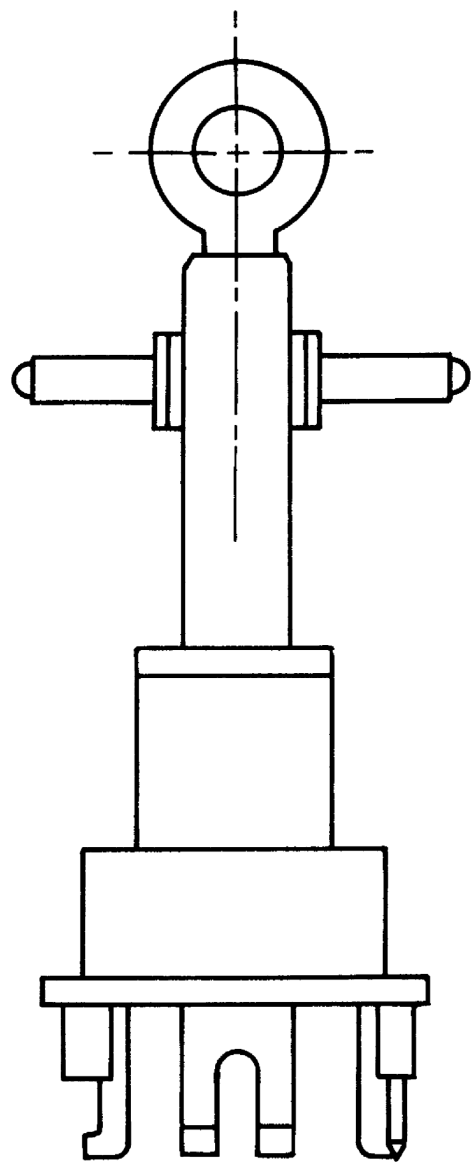


FIGURE 9.1–16 REACTOR INTERNALS LIFTING DEVICE

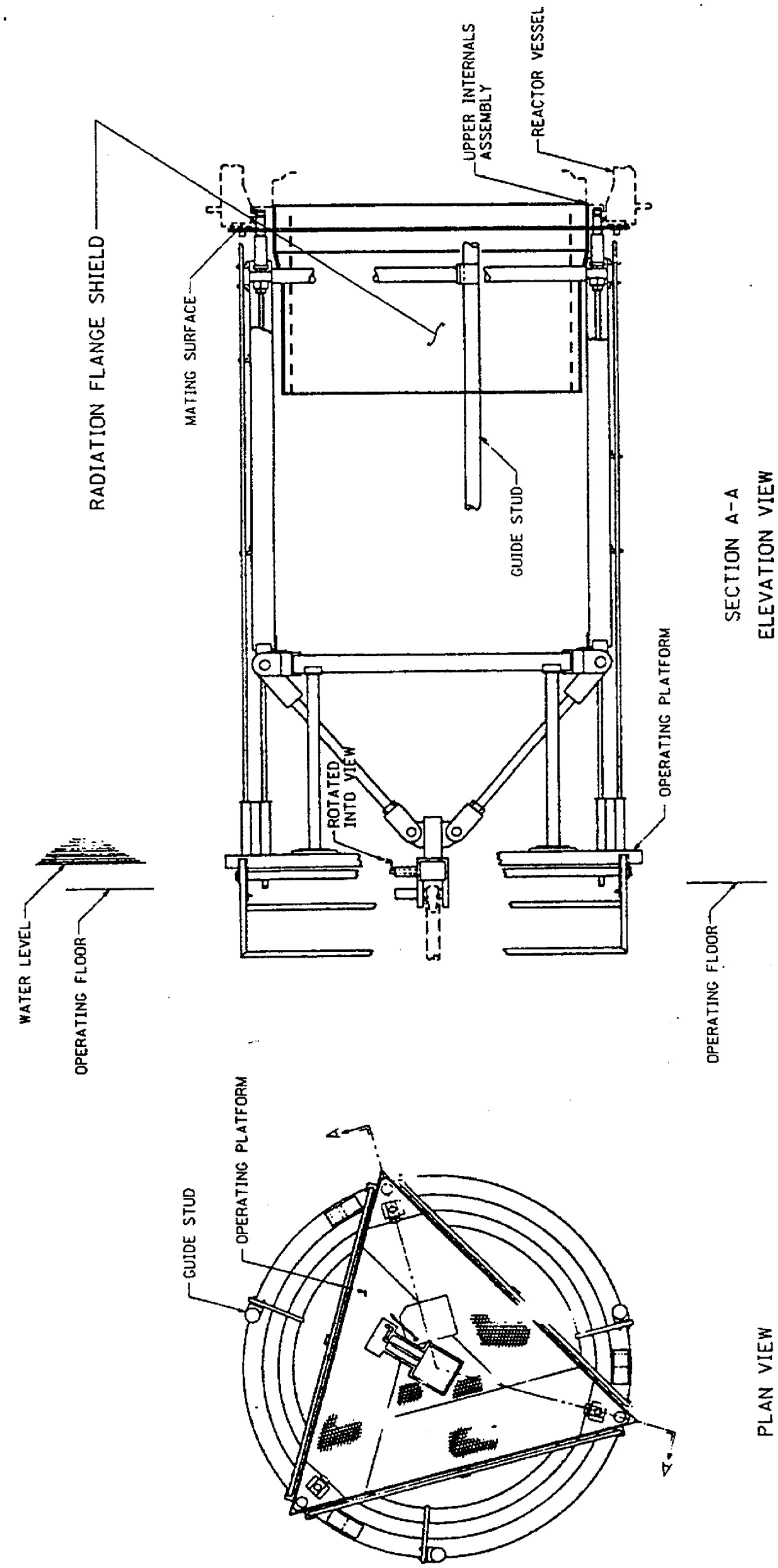


FIGURE 9.1–17 QUICK ACTING STUD TENSIONER (SHEET 1)

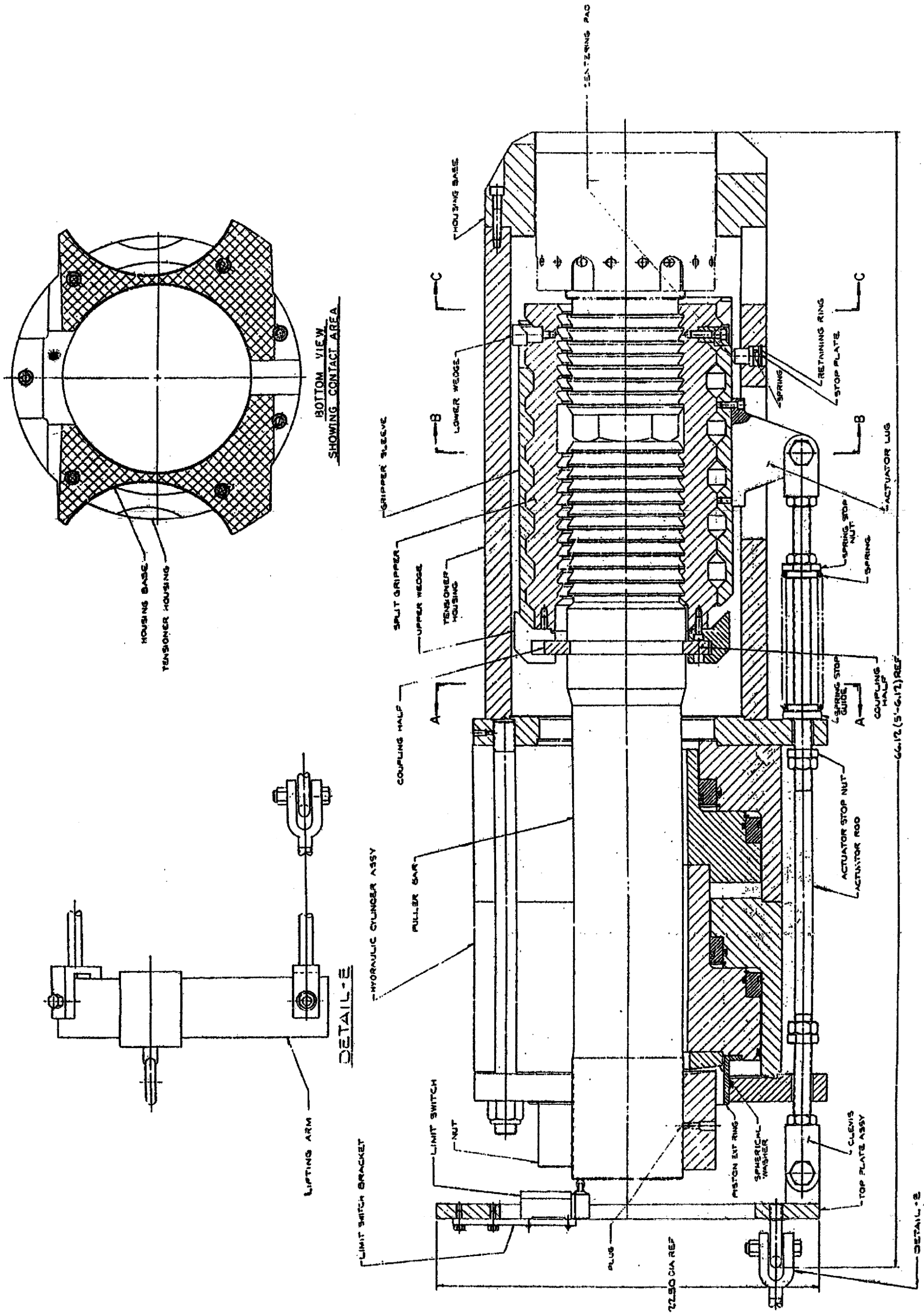


FIGURE 9.1–17 QUICK ACTING STUD TENSIONER (SHEET 2)

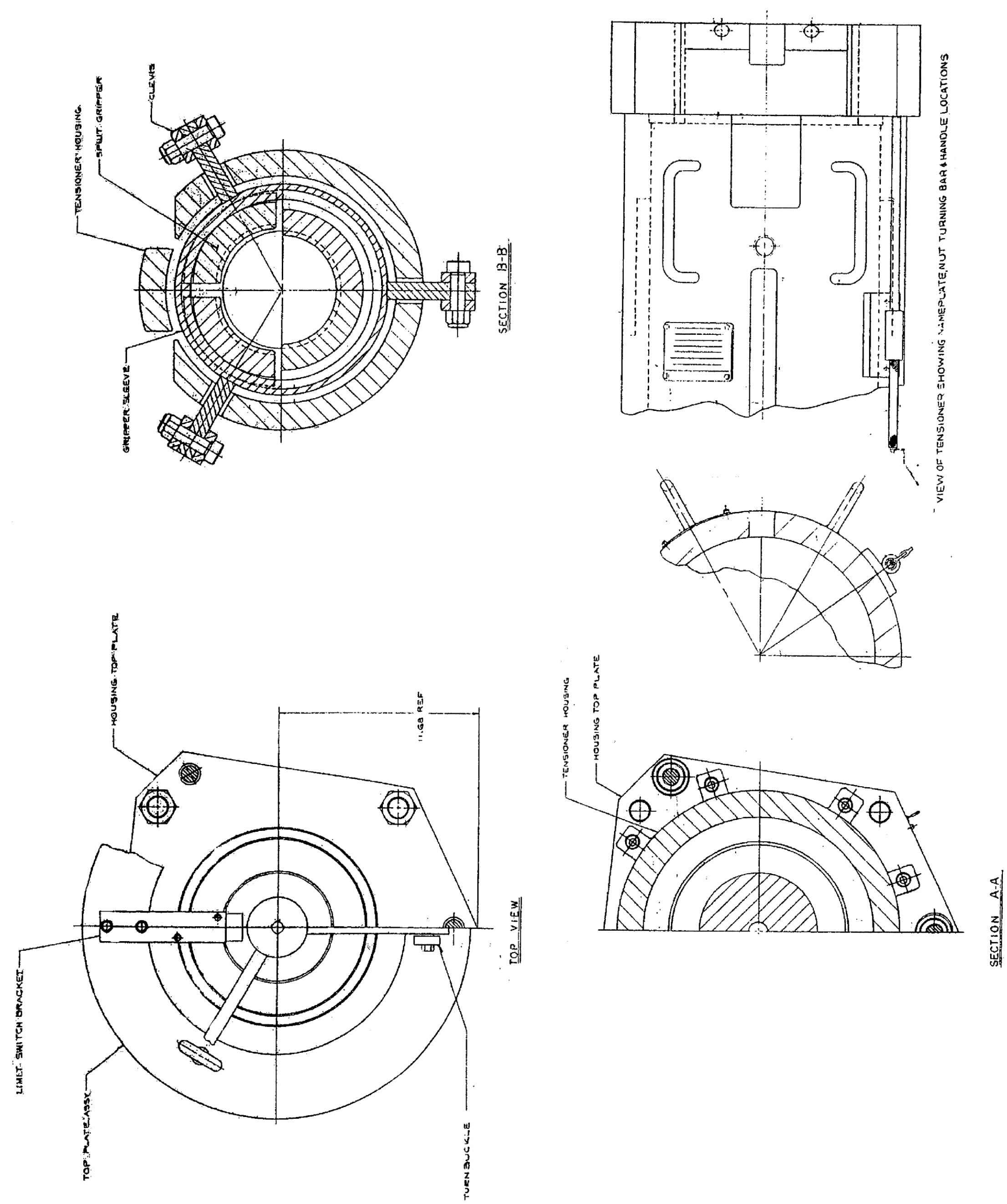


FIGURE 9.1–18 NEW FUEL VAULT LAYOUT

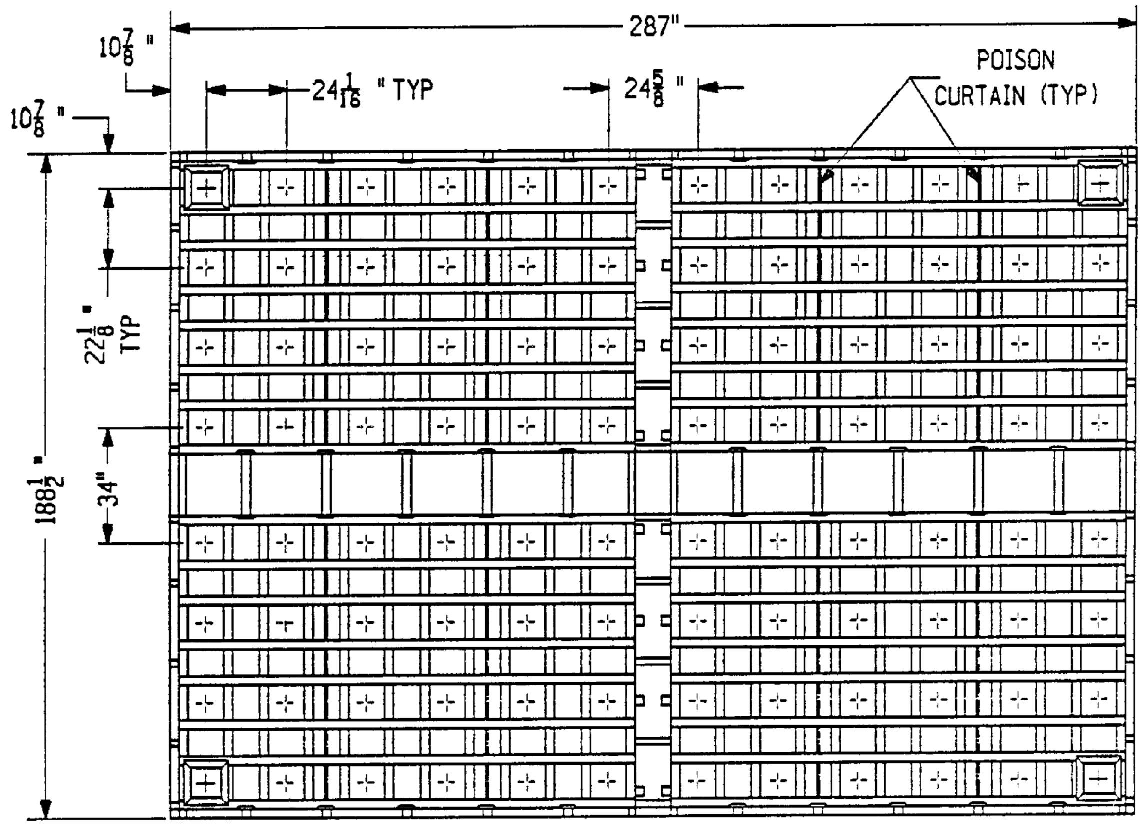


FIGURE 9.1–19 NEW FUEL VAULT ELEVATION VIEW

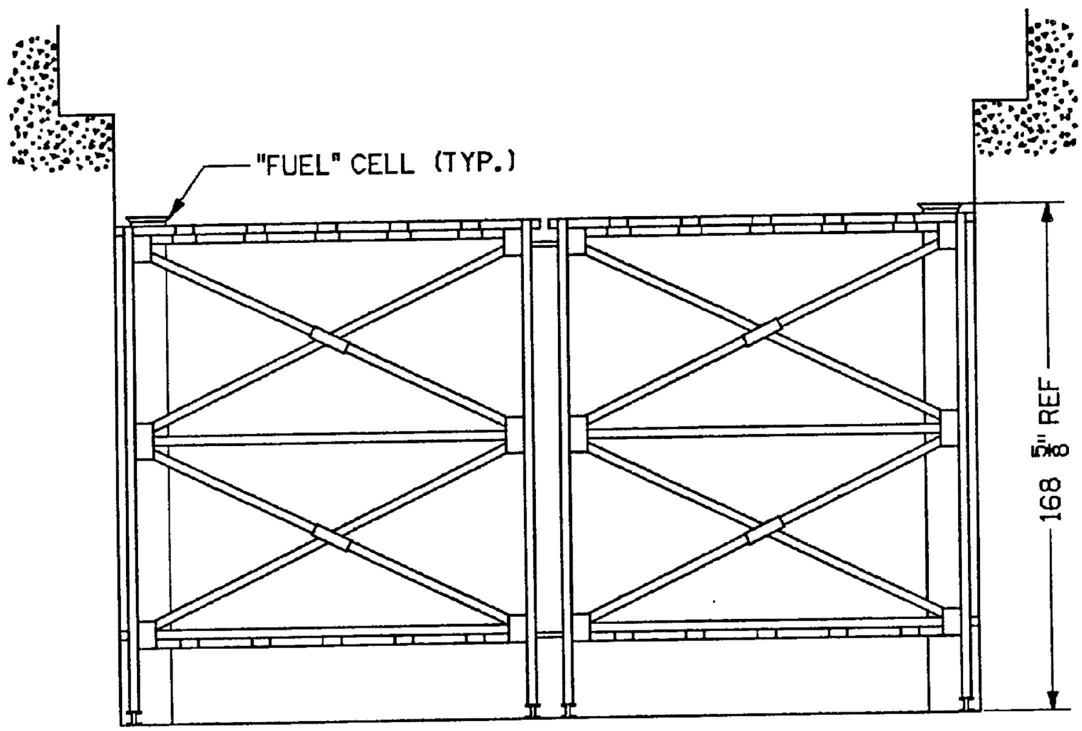


FIGURE 9.1–20 FUEL ASSEMBLY TRANSFER LIMIT VERSES CCP TEMPERATURE

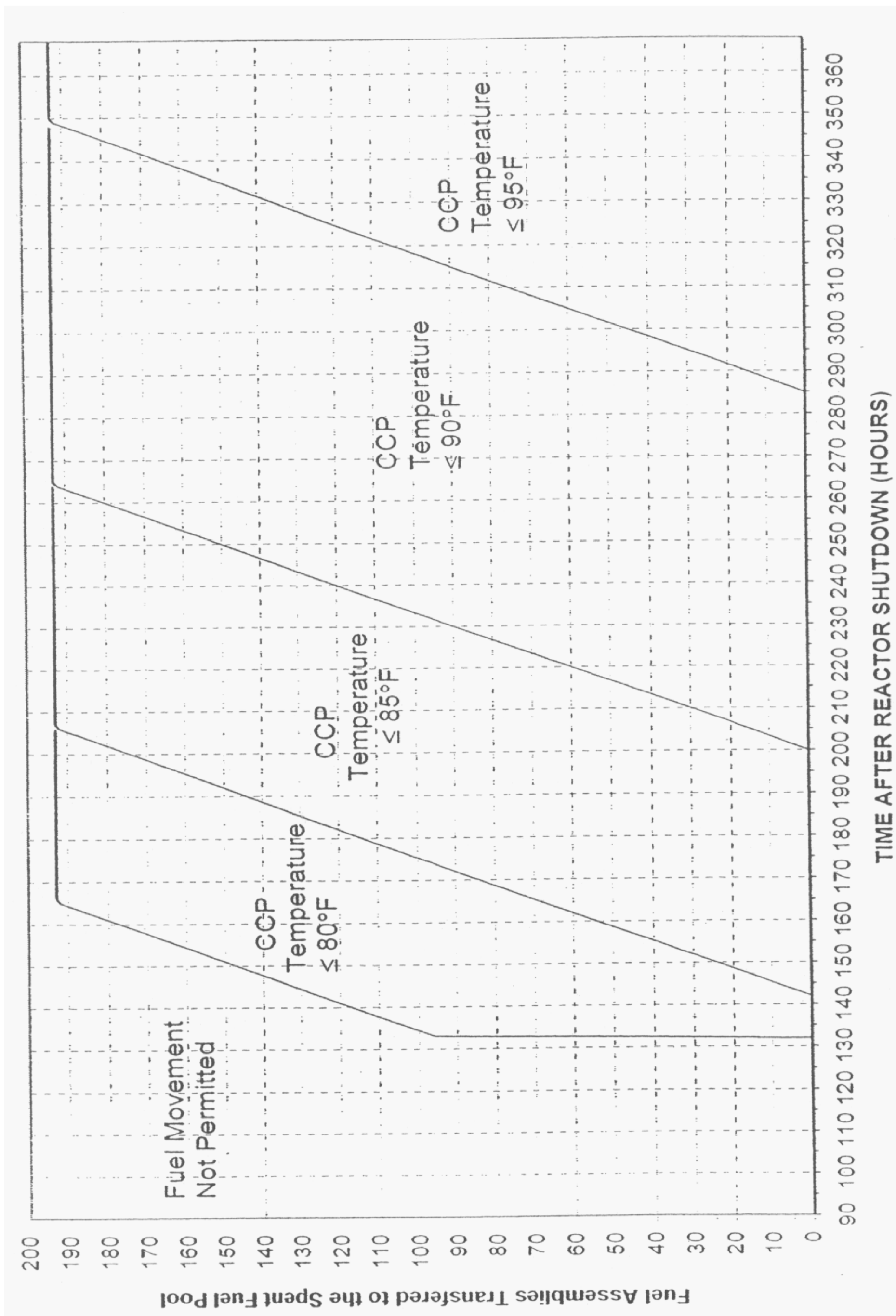


FIGURE 9.1–21 MILLSTONE UNIT 3 SPENT FUEL POOL LAYOUT

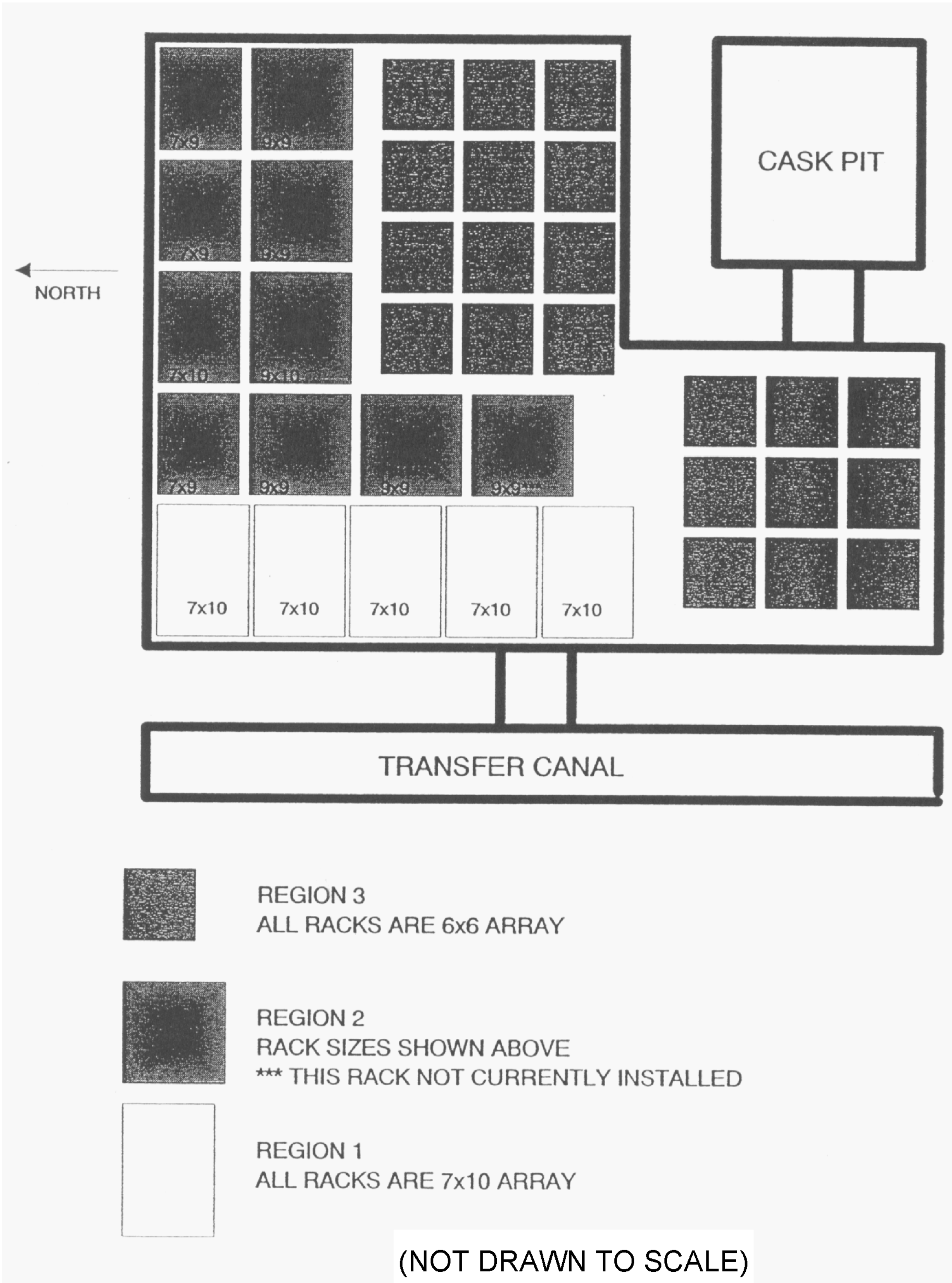
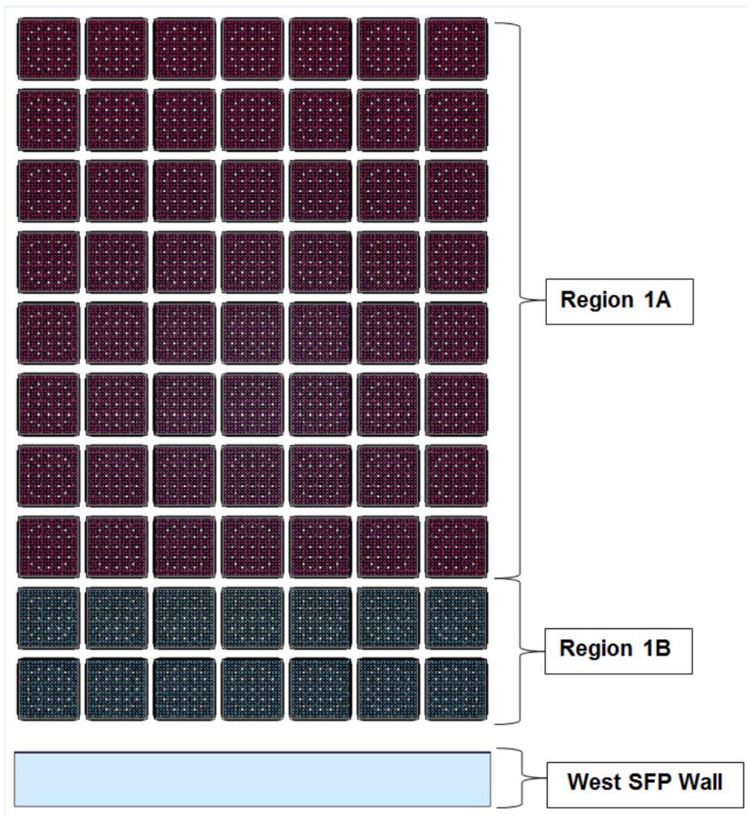


FIGURE 9.1–22 REGION 1 FUEL STORAGE LOADING SCHEMATIC



(NOT DRAWN TO SCALE)

FIGURE 9.1–22A PICTORIAL VIEW OF TYPICAL REGION 1 RACK MODULE

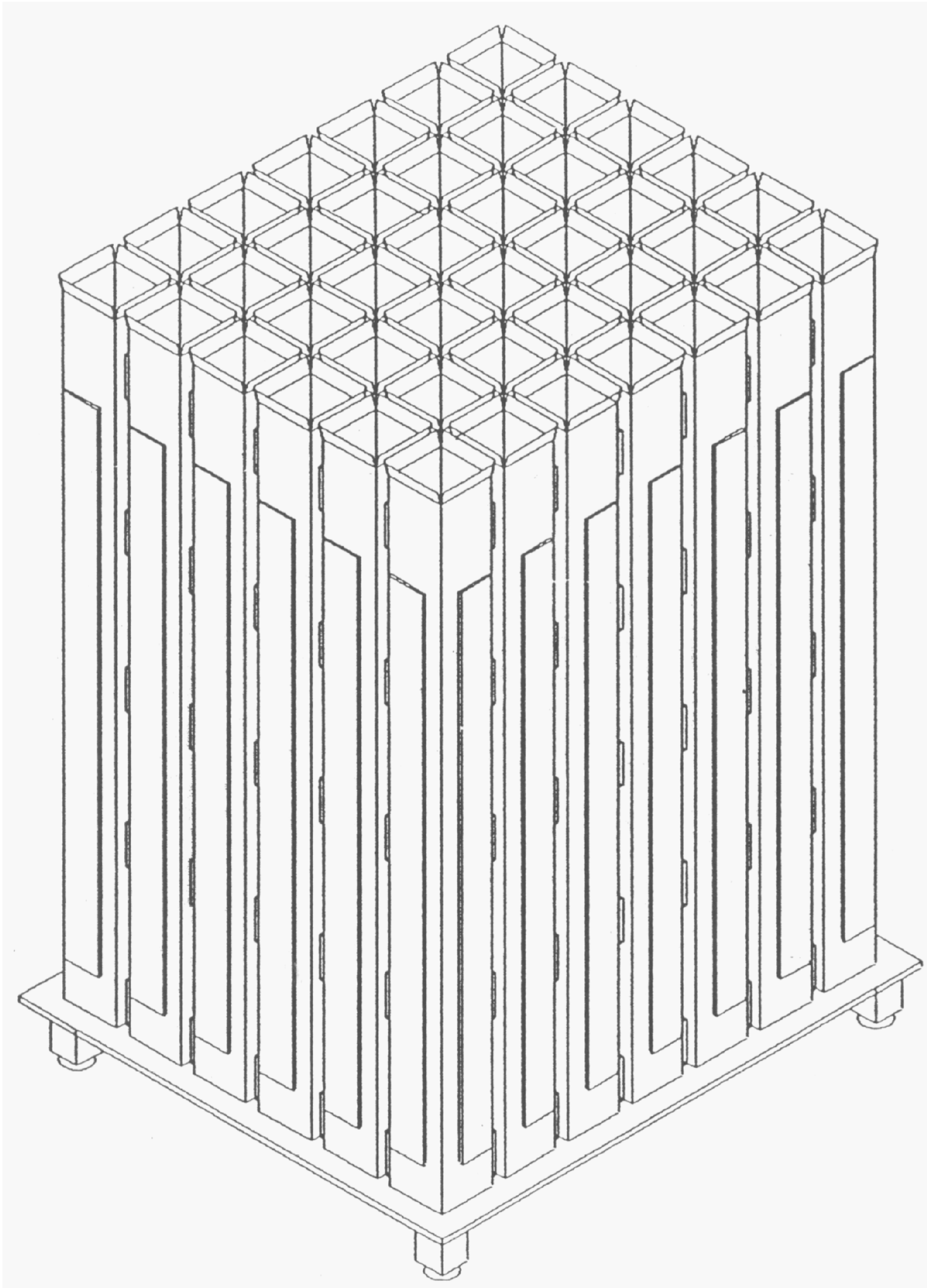


FIGURE 9.1–22B TYPICAL ASSEMBLAGE OF REGION 1 CELLS

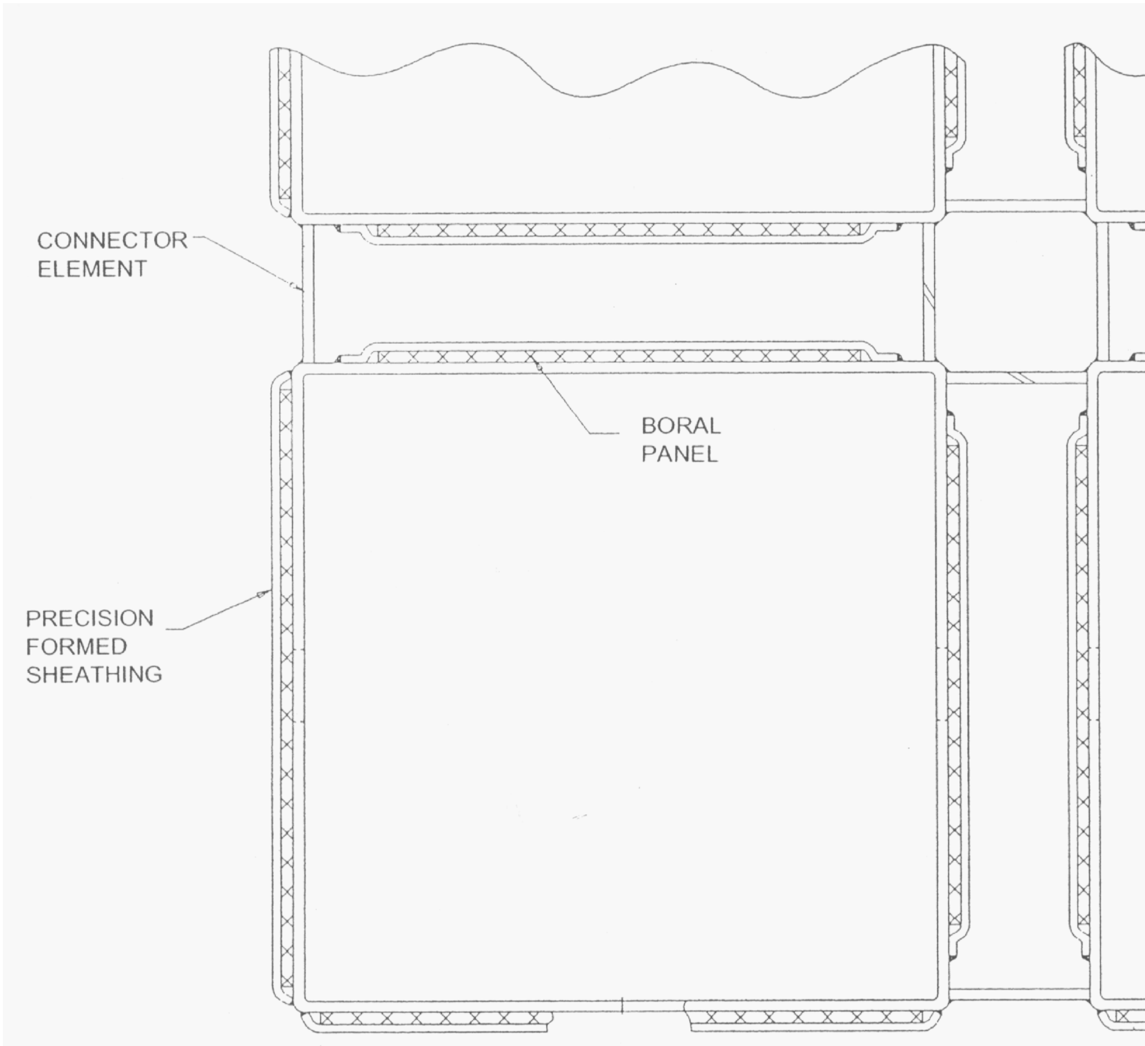


FIGURE 9.1–22C ELEVATION VIEW OF REGION 1 RACK MODULE

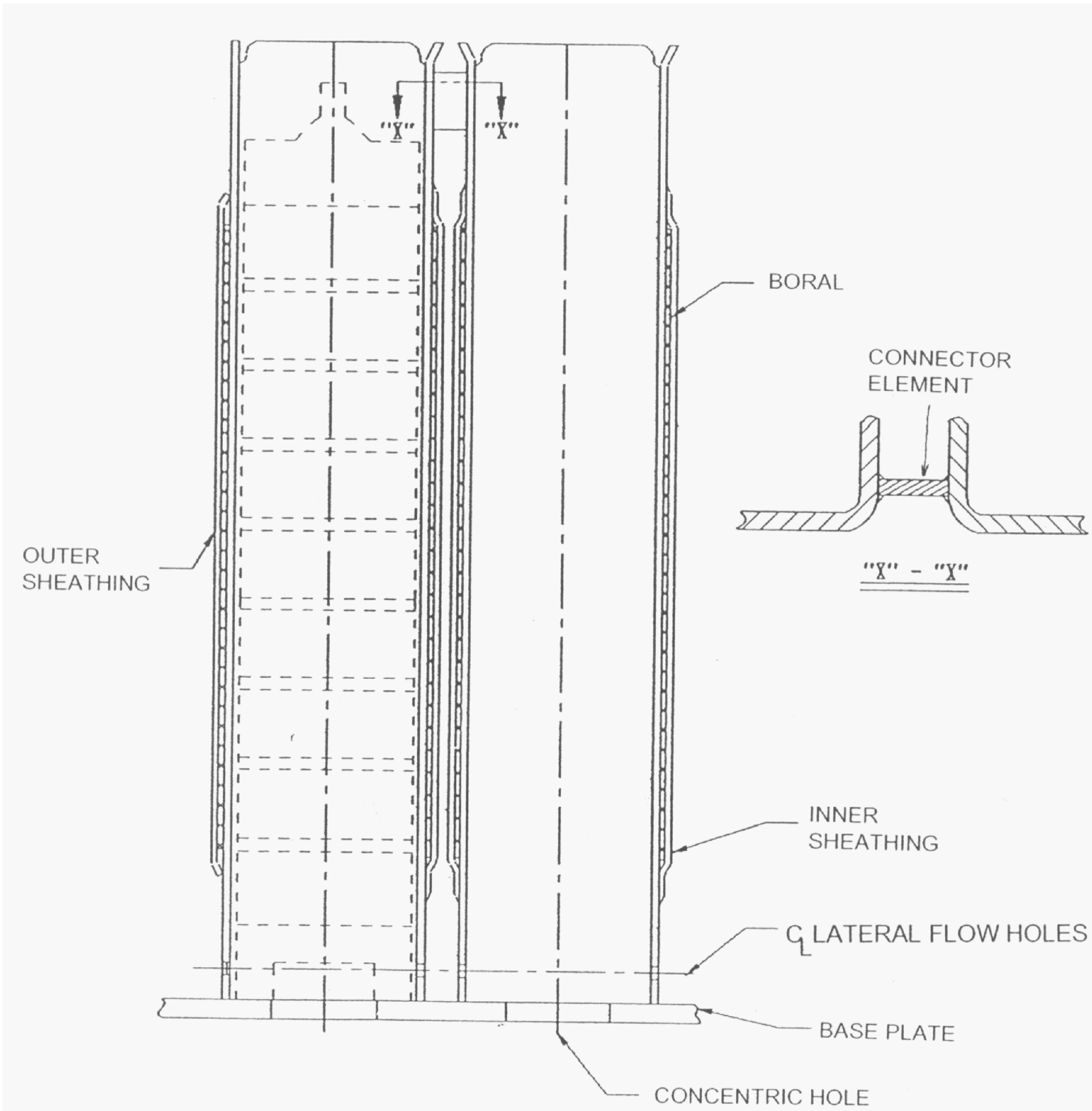


FIGURE 9.1–23 NOT USED

FIGURE 9.1–23A PICTORIAL VIEW OF TYPICAL REGION 2 RACK MODULE

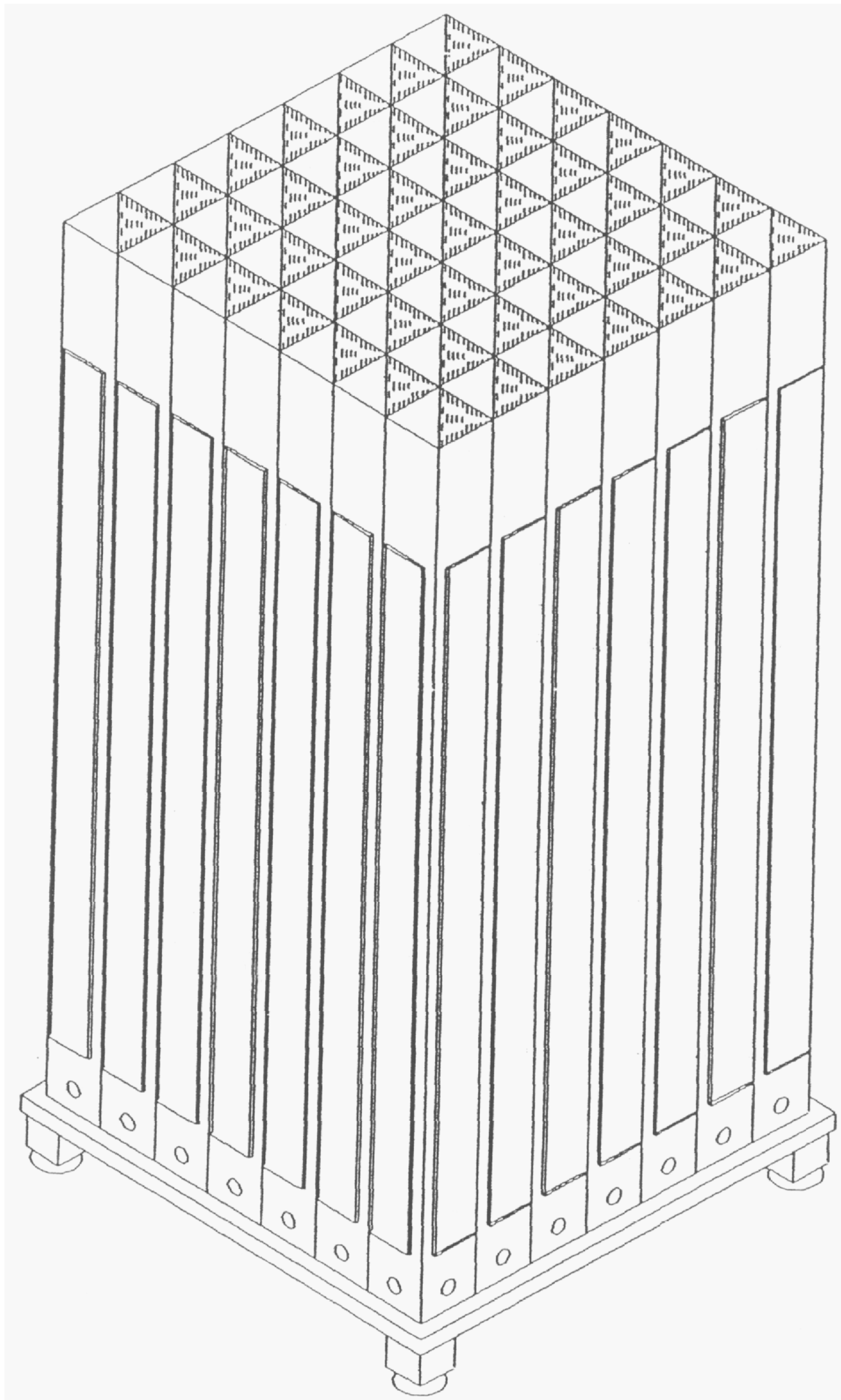


FIGURE 9.1–23B TYPICAL ARRAY OF REGION 2 CELLS

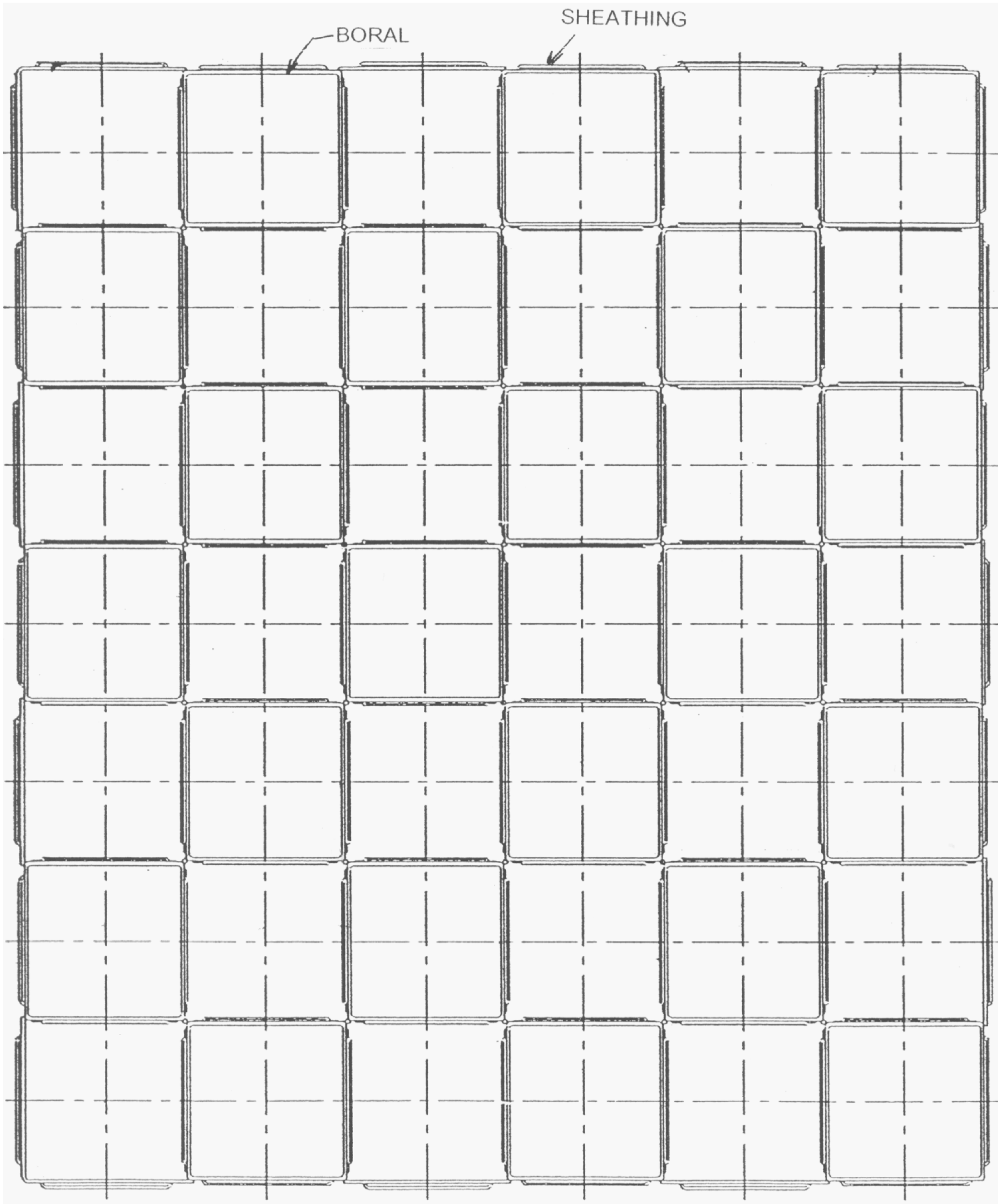


FIGURE 9.1–23C ELEVATION VIEW OF REGION 2 RACK MODULE

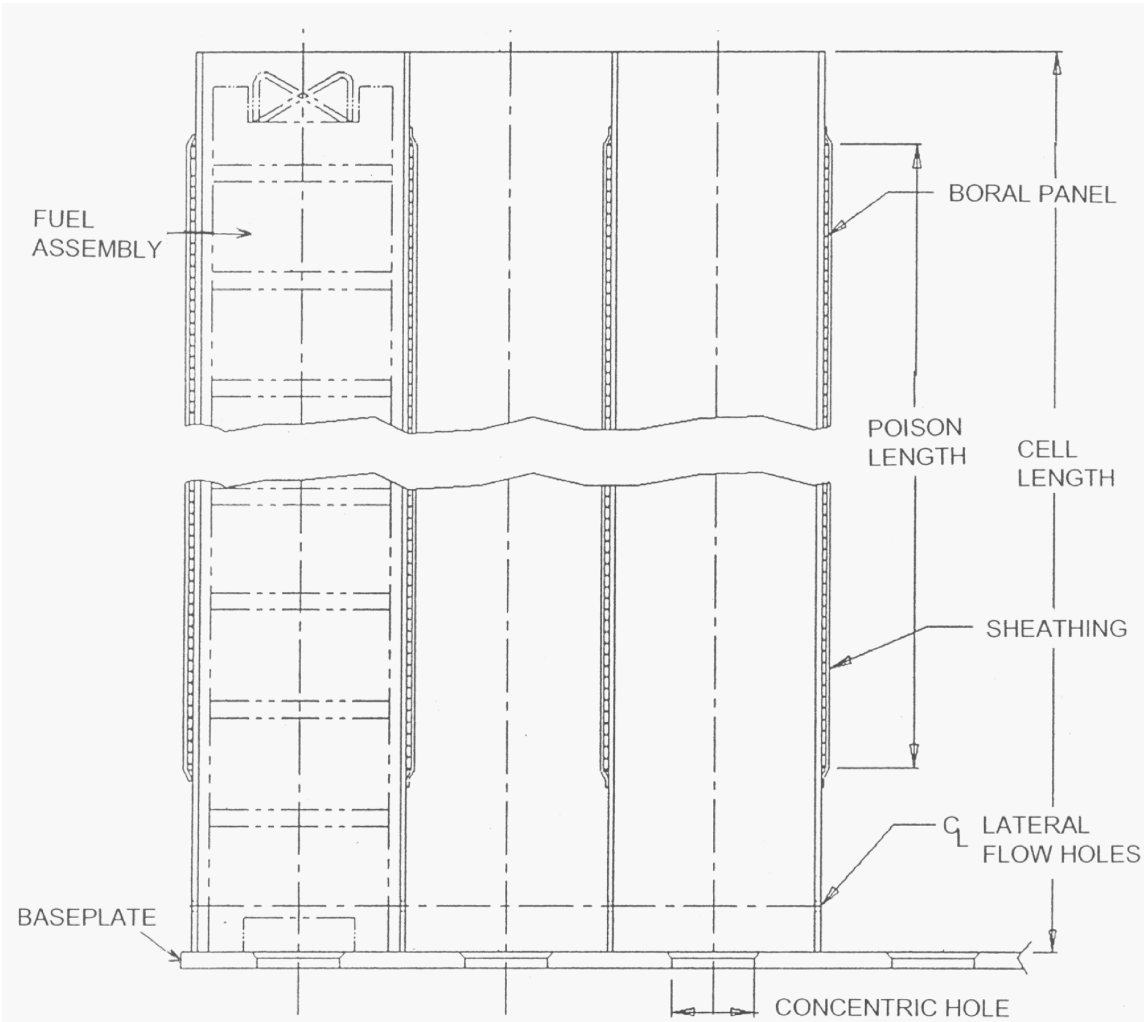
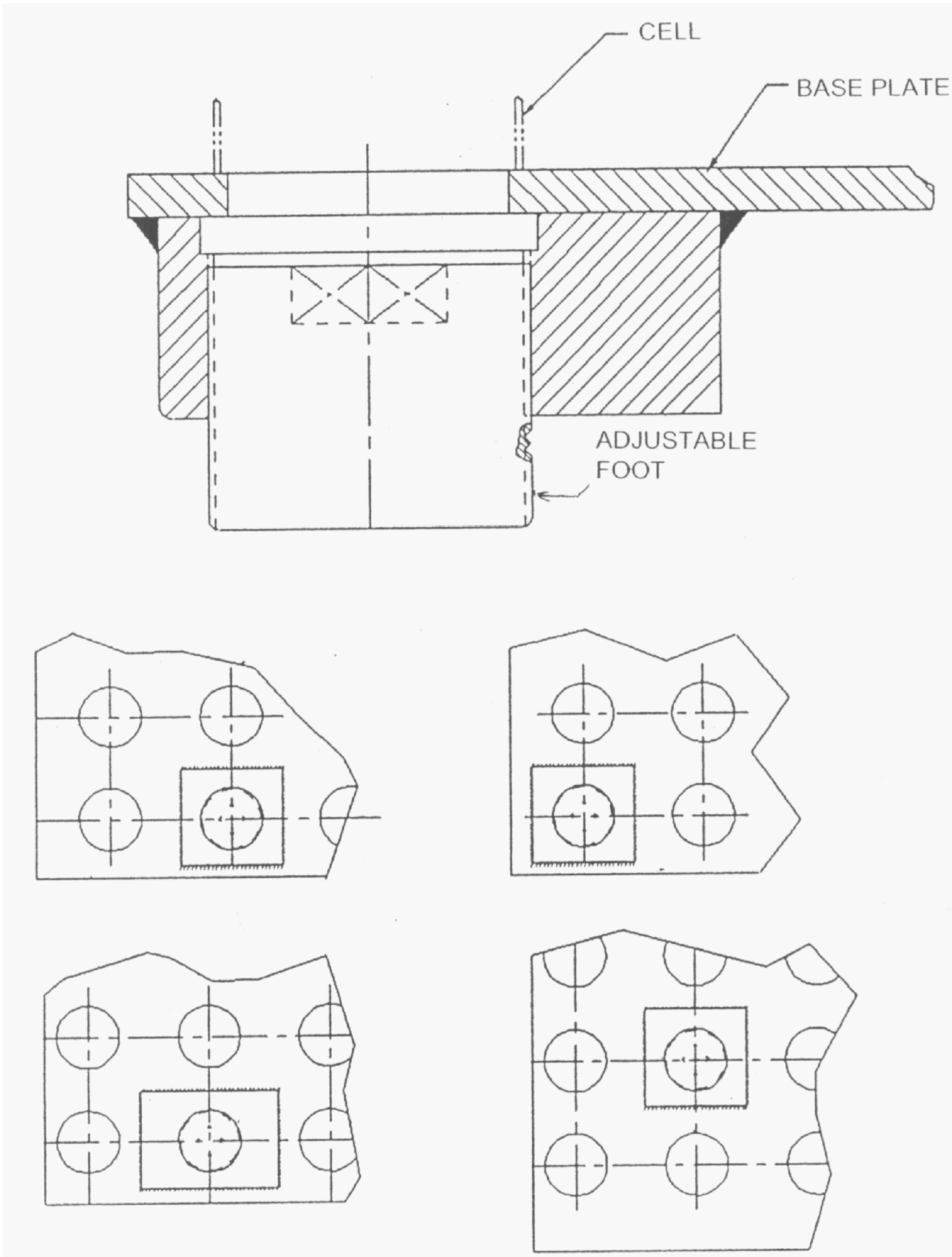


FIGURE 9.1–24 SUPPORT PEDESTAL FOR REGION 1 AND REGION 2 RACK MODULES



9.2 WATER SYSTEMS

9.2.1 SERVICE WATER SYSTEM

The service water system provides cooling water for heat removal from the reactor plant auxiliary systems during all modes of operation and from the turbine plant auxiliary systems during normal operation. Figure 9.2–1 shows the schematic of the service water system.

9.2.1.1 Design Bases

The service water system is designed in accordance with the following criteria:

1. General Design Criterion 2 for structures housing the system and the system itself being capable of withstanding the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, and floods

2. General Design Criterion 4 for structures housing the system and the system itself being capable of withstanding the effects of external missiles and internally generated missiles, pipe whip, and jet impingement forces associated with pipe breaks

3. General Design Criterion 5 for the capability of shared systems and components important to safety being capable of performing required safety functions

4. General Design Criterion 44, to assure:

    a. The capability to transfer heat loads from safety related structures, systems, and components to a heat sink under both normal operating and accident conditions

    b. Component redundancy so that the safety function can be performed assuming a single active component failure coincident with the loss of off site power (LOP)

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

5. General Design Criterion 45 for design provisions to permit inservice inspection of safety related components and equipment

6. General Design Criterion 46 for design provisions to permit operational, functional testing of safety related systems and components

7. Regulatory Guide 1.26 for the quality group classification of systems and components. The service water system supply and return piping for the post

accident sample cooler is designed to ANSI B31.1 requirements and is seismically qualified.

8. Regulatory Guide 1.29 for the seismic design classification of system components

9. Regulatory Guide 1.102 for the protection of structures, systems, and components important to safety from the effects of flooding

10. Regulatory Guide 1.117 for the protection of structures, systems, and components important to safety from the effects of tornado missiles

11. Branch Technical Position ASB 3-1 for breaks in high and moderate energy piping systems outside the containment

The design of the service water system achieves the following objectives:

1. To provide a continuous supply of cooling water, during startup and normal operating conditions, to the components listed in Table 9.2–1

2. To provide a continuous supply of cooling water, during normal unit cooldown conditions, to the components listed in Table 9.2–1

3. To provide a continuous supply of cooling water in the event of a loss-of-coolant accident (LOCA) to the engineered safety features (ESF) components listed in Table 9.2–1

4. To provide a continuous supply of cooling water, during loss of power (LOP), to the safety related equipment listed in Table 9.2–1

5. To provide an emergency source of makeup water to the fuel pool

6. To provide an emergency backup source of water to the auxiliary feedwater system and the control building chilled water system

Portions of the service water system operate in support of ESF systems acting to mitigate the consequences of accidents; such portions are, therefore, safety related and designed to QA Category I requirements, and in accordance with the codes and classifications given in Section 3.2.5 and in accordance with the separation and protection criteria discussed in Section 3.6.

The service water system provides cooling water during all operating conditions, at a maximum sea water temperature of 80°F coincident with either the service water pump design low water level (elevation minus 8.0 feet) or the maximum flood protection level (elevation plus 25.5 feet), and at all intermediate water levels.

The service water system accommodates individual isolation of all pumps, heat exchangers served by the systems, piping, strainers and control valves to maintain system operation during equipment repair and maintenance periods.

The service water pump operation for various modes of system operation are as follows:

Mode of Operation	Number of Service Water Pumps Required
Normal Operation	2
Normal Cooldown	2
DBA coincident with LOP	
Minimum ESF	1
Normal ESF	2
Loss of power	
Hot shutdown	2
Cold shutdown	1

The design pressure of the service water system is 100 psig, except for the service water pump discharge lines in and under the service water pump cubicles; the 6-inch lines immediately upstream and downstream of the control building air conditioning booster pumps suction valves; the lines between the upstream motor-operated valves and the containment recirculation coolers; the lines between the containment recirculation coolers and the downstream motor-operated valves, all of which have a design pressure of 97 psig; the discharge lines from the MCC and rod control area booster pumps, which have a design pressure of 145 psig; and the ESF Building discharge headers, which have a design pressure of 20 psig. The inlet operating temperature extremes of the service water system are 80°F maximum and 33°F minimum, determined by the ambient sea water temperature in Niantic Bay.

Table 9.2–1 lists the service water system flow requirements and Table 9.2–2 lists the service water system waste heat transfer requirements from the components listed to the ultimate heat sink, Long Island Sound (Section 9.2.5). These requirements are based on a maximum inlet service water temperature of 80°F.

The service water system and its components are designed for a plant life of 40 years.

9.2.1.2 System Description

The service water system consists of two redundant flow paths, each consisting of two service water pumps, two service water self cleaning strainers, two booster pumps, piping, and valves. The service water pumps and strainers are located in the circulating and service water pump house. The service water system discharges into the circulating water discharge tunnel.

The service water pumps are 15,000 gpm, 120 feet total dynamic head (tdh), AC motor driven vertical wet pit-type pumps. They are floor mounted and take suction from Niantic Bay from four separate bays below the operating floor of the circulating and service water pump house (Section 3.8.1). The suction bell of each of the pumps is located at elevation minus 13 feet (msl), 5 feet below their design low water level.

Each pump discharges through a separate self-cleaning strainer. The debris removed from the service water is cleaned from the strainer by backwash flow through the filtering elements. The backwash flow is 650 gpm at a service water pressure of 20 psig. Backwashing is not a continuous operation. It is an automatic operation initiated by a pressure differential across the strainer greater than 4 psi. The maximum passable particle size through the service water pump self-cleaning strainers is 0.0625 inch.

The operating floor (elevation plus 14.5 feet msl) of the circulating and service water pump house is divided by fire and missile protected watertight walls into two pump compartments: one for housing the non safety related circulating water and screen wash pumps and associated equipment, and the other for housing the safety related service water pumps and strainers. The service water pump compartment is further divided by a fire and missile protected watertight wall into two cubicles, each cubicle containing two service water pumps and associated self cleaning strainers.

The switchgear for each service water pump is located in the control building. The pump motors in one cubicle are powered from one emergency bus, and the pump motors in the other cubicle are powered from the other emergency bus.

Lubricating water for the circulating water pumps is filtered again after it has passed through the service water pump discharge strainers. The service water pumps are capable of operating without lubricating water. The strainers in the circulating water pump lubricating water lines pass a maximum particle size of 250 microns.

During normal operating and unit cooldown conditions, one service water pump on each redundant header discharges through the components listed in Table 9.2–1 and then into the circulating water discharge tunnel. The remaining pump on each header is on standby and starts automatically on a low pressure signal from its service water discharge header.

The control building air conditioning booster pumps, one on each service water header, provide the additional head required to circulate service water through the control building air-conditioning water chiller condenser. Each control building air conditioning booster pump is a 500 gpm, 45 feet total dynamic head, AC motor driven horizontal centrifugal pump. Each pump motor is powered from a separate emergency bus in the Class IE power system (Section 8.3.1).

The control building air conditioning water chillers may experience difficulty in starting when the service water temperature is below 55°F. During startup when the control building chilled water heat load is not large enough to evaporate sufficient refrigerant in the evaporator to overcome this effect, the chiller would trip due to low compressor suction pressure. To alleviate this problem, a control building water chiller condenser recirculation valve is provided in the service water discharge line. During periods of low service water temperatures, this valve recirculates an amount of heated service water discharging from the water chiller condenser and mixes it with the cold service water entering the booster pump suction to achieve an inlet temperature above 55°F. The temperature control valve is powered from an emergency electrical bus to ensure its operability following a LOP. Service water system piping connections supply cooling water directly to the cooling coils of the air conditioning units in case both chillers become simultaneously inoperable.

The motor control center (MCC) and rod control area booster pumps, one on each service water header, provide the additional head required to circulate service water through the MCC and rod control area air conditioning units when chilled water flow to these units is lost. Each MCC and rod control area booster pump is a 175 gpm, 105 foot tdh, AC motor-driven horizontal centrifugal pump. In the event of a high temperature in the return duct to the MCC and rod control area air-handling unit, or an LOP, the pumps will automatically start if the associated air conditioning unit is operating. Each pump motor is powered from a separate emergency bus in the emergency power system (Section 8.3.1).

For the emergency mode of operation, the supply lines to the non safety related equipment are isolated by automatic closure of isolation valves. A containment depressurization signal (CDA), or LOP, automatically closes the motor operated valves in the supply lines to the turbine plant component cooling heat exchangers (Section 9.2.2.1), circulating water pumps lube water. The non safety post accident liquid sample cooler is isolated during normal operations.

In the event of a LOCA or high energy line accident within the containment, a CDA signal closes the motor operated isolation valves in the service water supply lines to the reactor plant component cooling heat exchangers (Section 9.2.2.1) and opens motor operated isolation valves in the supply lines to the containment recirculation coolers. In such an accident coincident with a LOP, two service water pumps, each supplied by a separate emergency bus, start automatically.

During hot shutdown due to a LOP, two service water pumps operate with each pump motor supplied from a separate emergency bus. Whenever an emergency generator starts (Section 8.3.1), sufficient service water is supplied to the emergency generator diesel engine coolers by the automatic opening of air operated valves located in the discharge lines of each emergency generator diesel engine cooler. Under all operating conditions, flow is maintained through at least one of the two charging pump coolers and safety injection pump coolers.

Flow through the residual heat removal pumps ventilation units and containment recirculation pump ventilation units is automatically regulated by the amount of heat being dissipated through the unit. If there is no heat transferred in the ventilation units, the outlet valves are automatically closed.

Low pressure in the inlet supply lines to the turbine plant component cooling heat exchangers automatically closes isolation valves (MOV) in these lines.

An automatic control interlock prevents the opening of the reactor plant component cooling water heat exchanger isolation valves when the isolation valves to the containment recirculation coolers are open.

Several hours after the LOCA or a high energy pipe break accident and initiation of the CDA signal, it will be necessary to supply service water to the reactor plant component cooling heat exchangers for fuel pool cooling. This can be accomplished, first, by resetting the CDA signal. This arrangement then allows the inlet supply motor-operated valve for the reactor plant component cooling heat exchangers to be opened, in the train in which both service water pumps are running, while continuing to supply service water to the containment recirculation coolers. This results in a flow of at least 5400 gpm to each of two recirculation spray heat exchangers on the train with two service water pump operating.

The time required to re-establish Service Water to the Reactor Plant Component Cooling Water system following a LOCA is dependent upon the heat loads in the spent fuel pool. Service Water pump, strainer and discharge check valve maintenance activities are scheduled at times during the operating cycle when spent fuel pool heat loads are reduced.

The operating pressure of the service water system in the tubes of the reactor plant component cooling heat exchangers is less than the pressure of the shell side fluid. This precludes leakage of service water into the shell side fluid; leakage could cause excess fouling or detrimental chemical reactions between the service water and the components in the component cooling water system.

The automatic response of the service water system valves for various ESF signals is given in Table 9.2–3. The table shows the required valve position after initiation of an ESF signal.

Radiation monitoring equipment (Section 11.5.2.3) located at the discharge of each train of containment recirculation coolers detects leakage of radioactive contamination into the service water system from the containment recirculation coolers. Motor-operated isolation inlet and outlet valves at each containment recirculation cooler can be remotely closed to prevent contamination from escaping to the environment.

Materials resistant to corrosive attack from salt water are provided for all piping and component part surfaces in the service water system.

The use of epoxy coatings is considered a high technology application designed to protect the surface of the substrate from erosion and/or corrosion resulting from a saltwater environment. The coating material is applied to the inside surface of large bore service water system piping and selected components.

The use of a rubber sleeve with seals is considered an enhancement designed to protect the surface of the substrate from erosion and/or corrosion resulting from a saltwater environment. These pipe seals are installed in various locations in the Service Water piping to stop identified pipe erosion. Periodic surveillance will ensure that the seals remain in place preventing further degradation of the pipe.

Fouling protection for the components of the service water system is provided by chlorine solution injection downstream of each service water strainer.

The service water system is available to supply emergency makeup water to the auxiliary feedwater system. However, this design feature is only used, as an option of last resort, due to seawater's deleterious impact on steam generator tube integrity. Before the auxiliary feedwater pumps can take suction from the service water system, blank flanges must be removed and spool pieces installed to connect the service water system to the auxiliary feedwater system. These spool pieces are provided, in lieu of permanent piping, to preclude inadvertent discharging of service water to the steam generators.

The service water system provides an emergency source of makeup water to the fuel pool (Section 9.1.3), and acts as a backup supply to the auxiliary feedwater system (Section 10.4.9) and the control building chilled water system (Section 9.4.0).

9.2.1.3 Safety Evaluation

The service water system is Safety Class 3, missile protected, and Seismic Category I, except for the circulating water pumps lubricating water lines, the lines to and from the turbine plant component cooling heat exchangers, and the lines to and from the post-accident liquid sampling cooler. The circulating water discharge tunnel is a Seismic Category I structure.

TORMIS evaluation of the probability of failure of the SW vents above the ESF building and Service Water Blowdown piping external to the Circulating Service Water Pump House under a tornado missile has been completed and found to meet the requirements of SRP Section 3.5.2 and Section 2.2.3. See Section 9.5.8.3 for TORMIS limiting assumptions and exceptions.

In the chemical feed chlorination system, the line interfacing with the service water system including the isolation valves, is Safety Class 3, Seismic Category I. Service water pumps are not susceptible to pump house seismic failures since the service water pump cubicle, service water piping, and all reinforced concrete below the operating floor level are Seismic Category I.

The service water system is designed throughout to be able to perform its safety function following a single failure (Section 3.1.1). Power is supplied to redundant service water pumps from separate emergency buses. Each service water pump can supply the minimum cooling water requirements as specified during DBA conditions in Table 9.2–1. Thus, assuming the loss of one emergency bus or the failure of one service water pump to operate, the system safety function is ensured by a redundant emergency bus or a redundant pump.

Separate supply and discharge lines provide required cooling water to all redundant safety related components. This ensures that sufficient service water is provided to all safety related components listed in Table 9.2–1 following LOP and/or LOCA. Thus, assuming a single failure of one redundant supply or discharge line, the system safety function is achieved.

The system design permits maintenance to be performed on any component while providing the required cooling capability (Chapter 16).

A break in the service water piping is considered unlikely for the following reasons.

1. All safety related piping is buried or located within tornado protected seismically designed buildings.

2. All safety related piping is designed to meet Seismic Category I requirements.

Two control building air conditioning booster pumps are provided to ensure sufficient cooling water to the control building air conditioning water chiller condensers at a minimum service water temperature of 55°F, which is based on thermodynamic properties of Freon-12 (Section 9.4.0). Assuming a single failure of one control building air conditioning booster pump, the redundant pump performs the required safety function.

With a LOP, cooling water to the motor control center (MCC) and rod control area air conditioning units is supplied from the service water system. The MCC and rod control area booster pumps are provided to ensure sufficient cooling water to these air conditioning units.

Redundant motor-operated valves, receiving power from separate emergency buses are used for isolation and diversion functions. The failure of a single valve to operate will not prevent the service water system from supplying the minimum flow required to accomplish the required safety functions. Consequences of service water system component failures are shown in Table 9.2–4.

The service water system does not normally contain radioactive water. Provisions preclude the possible spread of radioactive contamination in the event that a leak into the service water system should occur. These precautions include radiation monitoring at the discharge of each train of containment recirculation coolers. Motor-operated isolation valves are located at each inlet and outlet line of the containment recirculation coolers so that, from the control room, each recirculation cooler can be isolated from the main header and the other recirculation cooler of the same train.

Pressure relief valves are provided throughout the service water system to preclude system overpressurization.

9.2.1.4 Inspection and Testing Requirements

The service water system is inspected during installation to ensure that all components meet their specifications and are properly installed.

The Class 3 portion of the service water system is tested, as required, by the ASME Code. The service water pumps are rotated in service for uniform wear.

The major portion of the service water system is continually in use and is monitored and observed by shift personnel to assure continued safe operation of the system.

Heat exchanger fouling and other component degradation is common in open cycle Service Water systems due to both macro and micro fouling. This fouling can lead to an inability to provide the safety related cooling that is the function of the Service Water system. NRC Generic Letter (GL) 89-13 required that actions be taken to confirm and maintain the capability of the Service Water system to perform its design basis functions. Actions performed to ensure the capability of the system to provide the required safety related cooling include:

- Injecting sodium hypochlorite to minimize biofouling. This injection prevents the attachment and subsequent growth of large quantities of mussels.

- Inspecting and cleaning the intake bays to minimize fouling. This cleaning removes fouling that might be drawn into the Service Water system and clog downstream components.

- Flowing Service Water through normally stagnant portions of piping such as supply to the containment recirculation coolers, diesel generators and ESF ventilation condensers to minimize fouling. Stagnant and near stagnant water can be conducive to biological growth.

- Monitoring of available heat exchanger parameters to detect gross debris loading. This periodic monitoring detects fouling build up in a heat exchanger between visual inspections.

- Inspecting heat exchanger, pipe, and other component internals on the Service Water side to remove fouling and repair as needed. Periodic inspections identify component degradation or the slow buildup of fouling prior to it affecting component operability.

- Cleaning heat exchangers on the Service Water side to minimize fouling buildup. Cleaning removes deposits of fouling that tend to occur in heat exchanger tubes.

- Tested heat exchangers to confirm design heat transfer capability. This testing and subsequent analysis verified heat exchanger performance was capable of meeting minimum design requirements.

- Filling heat exchangers with fresh water during lay-up to minimize buildup of fouling and component degradation caused by stagnant seawater.

9.2.1.5 Instrumentation Requirements

The service water system operating parameters are monitored, indicated, and controlled, locally or remotely.

Control of the service water pumps can be accomplished either from the main board in the control room or from the switchgear. A LOCAL/REMOTE selector switch on the switchgear, normally selected to REMOTE, determines which panel has control. An annunciator is alarmed on the main control board when LOCAL is selected. A STOP/AUTO/START control switch with indicating lights is located on both the main board and the switchgear for each service water pump. A selector switch for each Train (A, B) located on the switchgear, selects which pump is lead and which is lag.

The chemical feed-chlorination system isolation valves have main board OPEN/AUTO-CLOSE pushbuttons with indicating lights. The service water pump discharge valves are operated from the main board by an OPEN/AUTO pushbutton with indicating lights. The service water pump strainer motor is controlled from the main board by a OFF/AUTO/ON switch with indicating lights for the associated service water pump strainer backwash valve.

Annunciators on the main control board warn personnel of the following conditions:

1. Service water pump discharge pressure low
2. Service water flow low to emergency generator
3. Service water flow high to emergency generator
4. Service water pump at local control
5. Service water flow low to reactor plant component coolers
6. Service water flow high to reactor plant component coolers
7. Service water pump motor temperature high
8. Bus 34C load control power not available
9. Any motor control center loss of control power
10. Service water pump strainer differential pressure high
11. Service water pumps auto trip/overcurrent
12. Service water system train A bypassed
13. Service water system train B bypassed

Indicators are provided on the main control board for the following:

1. Service water pump motor current
2. Service water pump header discharge pressure

An engineered safety features status window is provided on the main control board to indicate that the service water pump is running.

Computer inputs are provided for the following system parameters:

1. Service water pump header discharge pressure
2. Service water pump breaker position
3. Deleted
4. Deleted
5. Service water pump motor temperature
6. Service water pump motor overcurrent
7. Service water pump auto trip
8. Service water pump A lead (one input for each pump)
9. Service water pump discharge valve open
10. Service water pump discharge valve closed
11. Service water pump strainer backwash valve open
12. Service water pump strainer backwash valve closed
13. Service water pump motor thrust bearing temperature
14. Service water pump motor radial bearing temperature
15. Air-conditioning unit molded case circuit breaker open
16. Air-conditioning unit control switch in PULL-TO-LOCK
17. Service water train A/B bypassed
18. BYPASS pushbutton depressed

Service water pump A control switch in PULL-TO-LOCK or control circuit open and service water pump C control switch in PULL-TO-LOCK or control circuit open (one input for pumps B and D also).

Indication of the service water pump motor current is available on the switchgear.

The service water pumps are sequenced on by the emergency generator load sequencer after a loss of emergency bus power has occurred.

Control switches and indicating lights for the MCC and rod control area booster pumps are provided on Ventilation Panel VP-1 in the control room.

9.2.2 COOLING SYSTEMS FOR REACTOR AUXILIARIES

The cooling systems for reactor auxiliaries consists of the reactor plant component cooling water, chilled water, neutron shield tank cooling, charging pumps cooling, and safety injection pumps cooling systems. These systems are used individually or in combination to provide cooling water for heat removal from reactor plant components.

Part of the reactor plant component cooling system, and the entire charging pumps cooling and safety injection pumps cooling systems are safety related. Tables 9.2–6, 9.2–11, and 9.2–13 present single failure evaluations of the equipment in each of these respective systems. These tables demonstrate the effect of a postulated failure of each piece of equipment on a safe reactor shutdown.

Capability to isolate the affected equipment in case of failure is discussed and listed in the above tables.

Single failure evaluations are not presented for the chilled water and neutron shield tank cooling systems since these systems are neither safety related nor required for a safe reactor shutdown (Sections 9.2.2.2 and 9.2.2.3).

9.2.2.1 Reactor Plant Component Cooling System

The reactor plant component cooling water system (CCP) provides an intermediate barrier between radioactive or potentially radioactive heat sources and the service water system (Section 9.2.1). It is designed to remove heat from various plant components in a manner which precludes direct leakage of radioactive fluids to the environment.

The reactor plant component cooling system is shown on Figure 9.2–2.

9.2.2.1.1 Design Basis

The reactor plant component cooling water system is designed for maximum normal unit operation. Design data (pressure, temperature, and capacity) of the major components in this system are presented in Table 9.2–5.

The reactor plant component cooling water heat exchangers and pumps, surge tank, and associated piping and valves are designed in accordance with the requirements of Seismic Category I and Safety Class 3. Piping to and from the residual heat removal heat exchangers, residual heat removal pump seal coolers, safety injection pumps cooling surge tank, fuel pool coolers, charging pumps cooling surge tank, seal water heat exchanger, letdown heat exchanger, excess letdown heat exchanger, and reactor coolant pumps bearing oil coolers and thermal barriers, is designed in accordance with the requirements of Seismic Category I and Safety Class 3. Containment piping penetrations are designated Safety Class 2, Seismic Category I. The rest of the system is nonseismic (except where required to prevent damage to safety related equipment in the event of an earthquake).

Both safety related and nonsafety related piping classes are shown on Figure 9.2–2.

To prevent the occurrence of service water leakage into the component cooling water, the component cooling water system is maintained at a higher pressure than the service water system.

Because the system is required to perform its safety function during the short-term and long-term plant accident conditions, the safety related passive components as well as the active components are designed to meet the single failure criteria. An analysis of postulated cracks in moderate energy systems is found in Section 3.6.

The component cooling water system is designed in accordance with the following criteria, regulatory guides, and codes:

1. Title 10, Code of Federal Regulations, Part 50, Appendix A, General Design Criteria (GDC) for Nuclear Power Plants GDC 2, 4, 5, 44, 45, 46, 54, 56, and 57, as specified in Section 3.1.2

2. NRC Regulatory Guides 1.26 and 1.29, as specified in Section 1.8

3. Codes used to design and fabricate this system are discussed in Section 3.2

9.2.2.1.2 System Description

The reactor plant component cooling water system is a closed loop cooling system that transfers heat from reactor auxiliaries to the service water system during plant operation and during normal and emergency cooldown/shutdown. Additionally, the reactor plant component cooling system provides makeup water to several cooling subsystems. The system consists of three half-capacity motor-driven cooling water pumps, three half-capacity heat exchangers, a surge tank, a chemical addition tank, associated piping, valves, instrumentation, controls and auxiliary electrical equipment.

Each of the three reactor plant component cooling heat exchangers is capable of removing one half of the heat load generated 4 hours after the start of unit cooldown. The reactor plant component cooling water system is designed to supply 95°F during normal plant operation when the service water is at its maximum design temperature of 80°F. For normal cooldown and safety grade cold shutdown, the component cooling water supply temperature may reach 110°F and 113°F, respectively, due to higher residual heat removal heat duty.

The reactor plant component cooling system supplies water to cool the following reactor plant components located inside the containment structure:

1. Reactor coolant pumps (thermal barriers, upper and lower bearing oil coolers) (Section 5.4.1)

2. Excess letdown heat exchanger (intermittent heat load) (Section 9.3.4)

3. Containment air recirculation cooling coils (loss of power or SIS (CIA) only (Section 9.4.6.2)

4. On service neutron shield tank cooler (loss of power or SIS (CIA) only) (Section 9.2.2.3)

The following components cooled by the reactor plant component cooling water system are located outside the containment structure:

Safety Related Components

1. Seal water heat exchanger (Section 9.3.4)

2. Letdown heat exchanger (Section 9.3.4)

3. Fuel pool coolers (during storage of spent fuel in fuel pool) (Section 9.1.3)

4. Residual heat removal pumps seal coolers (during cooldown) (Section 5.4.7)

5. Residual heat removal heat exchangers (during cooldown) (Section 5.4.7)

Non safety Related Components

1. Thermal regeneration chiller (Section 9.3.4)

2. Radioactive liquid waste system equipment: waste evaporator condenser, waste distillate cooler, waste evaporator bottoms cooler (intermittent heat load) (Section 11.2) This equipment is no longer in service.

3. Radioactive gaseous waste system equipment: degasifier condenser, degasifier trim cooler, process gas compressors (head and precoolers) (Section 11.3)

4. Boron recovery system equipment: boron evaporator bottoms cooler, boron distillate cooler, boron evaporator condenser (intermittent heat load) (Section 9.3.5)

5. Chilled water system mechanical refrigeration units (Section 9.2.2.2)

6. Reactor plant sample coolers (intermittent heat load (Section 9.3.2)

7. Reactor plant sampling system chiller assembly (Section 9.3.2)

8. Auxiliary condensate system sample coolers (Section 10.4.10)

9. Auxiliary condensate system cooler (Section 10.4.10)

10. Containment structure penetration coolers (Section 9.2.2.1)

11. Cold Shutdown Instrument air compressors and after coolers (normally isolated)

12. Metrology Lab Heat Pump

In addition, the reactor plant component cooling water system supplies makeup water to the following:

1. Safety injection pumps cooling surge tank (Section 9.2.2.5)

2. Chilled water surge tank (Section 9.2.2.2)

3. Charging pumps cooling surge tank (Section 9.2.2.4)

4. Thermal regeneration chiller surge tank (Section 9.3.4)

5. Fuel transfer system (Section 9.1.4)

6. Reactor plant component cooling water piping, supplied by condensate makeup and drawoff system, supplies sill cock plumbing in various buildings

The reactor plant component cooling water system is designed as a closed system. Variations in volume, due to temperature changes, are accommodated by the reactor plant component cooling surge tank connected at the reactor plant component cooling pump suctions. The reactor plant component cooling surge tank is the high point of the system, and provides the net positive suction head for the reactor plant component cooling pumps.

The surge tank is compartmented by an internal partition so that a rapid loss of water from one compartment of the surge tank affects only one reactor plant component cooling pump, leaving the other reactor plant component cooling pump unaffected and fully capable of safely cooling down the unit if necessary.

The reactor plant component cooling surge tank level is controlled automatically. The tank capacity is sufficient to accommodate minor system surges, thermal expansion and contraction, isolation of a moderate energy line break, and 30 day system leakage. The reactor plant component cooling surge tank is provided with one high level alarm and one low level alarm to alert the operator to a possible malfunction of the makeup valve, or system leakage.

Makeup is supplied from the condensate makeup and drawoff system (Section 10.4.10) automatically controlled by surge tank level controllers.

The excess letdown heat exchanger and a pair of reactor coolant pump coolers are supplied by a component cooling water line which penetrates the containment. Another line independently supplies the second pair of reactor coolant pump coolers. The two supply lines and the two return lines are cross connected to each other, respectively. During normal operation, the two cross connections are closed to better balance the operation of the two component cooling water trains. In the event of a reactor plant component cooling water pump failure, cooling water is supplied to all reactor coolant pump coolers via these cross connections. To limit temperature in containment during off normal conditions, the containment air recirculation coolers and the neutron shield tank coolers, normally cooled by the chilled water system (Section 9.2.2.2), may be cross connected to the reactor plant component cooling water system. Automatic valves are provided that cross connect these nonsafety related components in the chilled water system to the safety related supply and return lines in the reactor plant component cooling water system. These valves open upon loss of power (LOP) or SIS (CIA) or Loss of Power (LOP) signal.

The reactor plant component cooling water supply and return lines penetrating the containment are isolated upon receipt of a DBA (CIB) signal. The containment isolation valve arrangement for the reactor plant component cooling water system is shown in Section 6.2.4. During an SIS (CIA) the lines penetrating the containment are not isolated and the system continues to operate.

Redundant pipelines, residual heat exchangers and residual heat removal pump seal coolers are provided so that, in the event of a single failure, the unit can be brought to cold shutdown. Remotely actuated valves are provided in the reactor plant component cooling water system to isolate the piping outside containment which is nonsafety related from that which is safety related. In the event of a rupture in nonsafety related piping as sensed by low surge tank level, the damaged piping is isolated by automatic closure of remotely actuated valves. These valves also close upon a SIS (CIA) or loss of power (LOP) signal.

Redundant remotely actuated valves are provided in the containment loop header to completely isolate each side of the seismically designed system from the other. In the event of piping failure of either non safety related piping or single passive pipe crack (MEB 3-1) in safety related piping (as sensed by low surge tank level), automatic closure of these containment loop header valves ensures separation of the system. Half of the reactor plant component cooling water system is available to reduce reactor coolant system temperature to cold shutdown conditions using the residual heat removal system. Wherever a safety related pipe crack is postulated, at least one half of the safety related portion of the reactor plant component cooling water system will retain sufficient water to accomplish safety objectives. At the time of isolation, the quantity of water stored in each half of the reactor plant component cooling surge tank is sufficient to allow continued operation.

Valves are located to allow any component within the reactor plant component cooling water system to be isolated from the remainder of the system.

During normal operation, two reactor plant component cooling pumps and two reactor plant component cooling heat exchangers accommodate the heat removal load. A third pump and heat exchanger are provided as installed spares to permit maintenance of either of the other pumps and heat exchangers while retaining two train systems operations. Double manual valves are provided in the suction and discharge headers to allow connection to either of the redundant safety trains.

The reactor plant component cooling water system is provided with containment isolation valves for isolating the containment structure, in accordance with the requirements of the containment isolation system (Section 6.2.4).

Cooling water return lines from each reactor plant component, except the chilled water chiller units, contain valves for controlling flow. The chilled water chiller units have flow control valves in their supply lines. The valves are either manually operated gate, butterfly, globe or ball type positioned before unit startup, automatic type positioned by pressure or temperature control signals originating in the cooled systems, or manually controlled from the control room using flow indication in the control room.

Thermal relief valves are provided on all equipment which might be overpressurized by a combination of closed reactor plant component cooling water inlet and outlet valves, and heat input from the isolated equipment.

A reactor plant component cooling chemical addition tank is connected to the reactor plant component cooling pumps discharge and suction piping. The required water chemistry is obtained by the addition of hydrazine to control long term corrosion of the system. Organic fouling of the heat exchangers is not expected due to system water chemistry and the chlorination of the service water system.

9.2.2.1.3 Safety Evaluation

The reactor plant component cooling water system uses equipment and reactor plant components of conventional and proven design. All reactor plant components are specified to provide maximum safety and reliability.

A single failure evaluation of postulated reactor plant component cooling water system components is presented in Table 9.2–6.

A tornado has no effect on the component cooling water system service to safety related equipment because the safety related portions are located inside Seismic Category I tornado, missile, and flood protected buildings.

Redundant Seismic Category I piping, residual heat exchangers and residual heat removal pumps seal coolers ensures a safe unit cooldown in the event of a single failure. The safety grade cold shutdown process is described in Section 5.4.7.2.3.5. The piping to the fuel pool coolers, seal water heat exchanger, letdown heat exchanger, safety injection pumps cooling surge tank, charging pumps cooling surge tank, excess letdown heat exchanger and reactor coolant pumps coolers, is also Seismic Category I to ensure the safe operation of the unit.

Low or high flow, low pressure, low or high surge tank level, high temperature, and high radioactivity alarms alert the operator to malfunctions in the system. A radiation alarm alerts the operator to check the reactor plant components serviced for leakage of radioactive fluid into the reactor plant component cooling water system.

During normal operation, two reactor plant component cooling pumps and two reactor plant component cooling heat exchangers accommodate the heat removal load. A spare pump and heat exchanger is provided to allow pump or heat exchanger maintenance. One reactor plant component cooling pump is fed by one emergency bus, a second reactor plant component cooling pump is fed by the second redundant emergency bus, while the spare reactor plant component cooling pump may be manually connected to either emergency bus (Figure 8.1.1). During accident conditions which do not cause a CDA signal, one reactor plant component cooling pump and one reactor plant component cooling heat exchanger accommodate the heat removal load. During accident conditions which cause a CDA signal, the CCP heat exchanger SW flow is automatically isolated and the CCP system is unavailable for transferring heat to the ultimate heat sink. A failure of one power supply train or any reactor plant component in one train does not prevent the system from performing its safety function.

Automatic air-operated valves are installed in the return cooling water lines from the reactor coolant pump thermal barriers (Figure 9.2–2). A check valve is installed in each cooling water supply line to the thermal barriers (Figure 9.2–2). In the event that a leak occurs in a thermal barrier cooling coil, a high flow signal in the reactor plant component cooling system closes the air operated valve and a resulting low flow alarm is annunciated in the control room.

In the event of a loss of cooling water supply, the reactor coolant pumps can be operated indefinitely without overheating as long as normal seal injection flow is being supplied. Loss of reactor plant component cooling water is indicated in the control room and sufficient time is provided for the operator to either correct the problem or trip the plant, if necessary. Redundant means of supplying information to the control room are provided by thermal barrier low flow alarms and by temperature detectors embedded in the bearing material which also alarm in the control room. In order to enhance the reliability of the cooling water supply to the reactor pumps, the following design feature has been provided.

The containment supply and return headers have the ability to be cross connected so that, if a reactor plant component cooling water pump fails, all four reactor coolant pumps can be supplied with cooling water from the unaffected pump. During normal operation the cross connect valves are closed.

Fail-as-is motor operated containment isolation valves are actuated only in the event of a CDA (CIB).

The reactor plant component cooling water system does not normally contain radioactive water. Provisions are made to preclude the possible spread of radioactive contamination in the event that a leak into the reactor plant component cooling water system should occur. These provisions include the capability of isolating each heat exchanger by manually closing the inlet and outlet reactor plant component cooling water valves. Welded construction is used extensively throughout the system to minimize the possibility of leakage from pipes, valves, and fittings. Radioactive contamination of reactor plant component cooling water could result from leakage between the tubes and shell of heat exchangers in the chemical and volume control, residual heat removal, fuel pool cooling, or reactor plant sampling systems, or from a leak in the thermal barrier of a reactor coolant pump. If radioactive contamination of the reactor plant component cooling system occurs, the source of contamination will be located and repaired.

Gross leakage from the reactor plant component cooling water system is primarily detected by falling surge tank level. Temperature, level, and flow indicators in the control room are used to detect leakage at certain points. Elsewhere, leaks are detected by inspection.

The reactor plant component cooling pumps and necessary instrumentation are located above building flood levels to allow operation following flooding conditions (external floods or pipe breaks). As an added precaution, the reactor plant component cooling pump motors are protected from damage due to water spray.

Potentially radioactive fluids cooled by the reactor plant component cooling water system are isolated from the environment by two barriers. The first barrier is the tube walls of the heat exchanger where the potentially radioactive fluid is cooled by the reactor plant component cooling water. The second barrier is the tube walls of the reactor plant component cooling heat exchanger where reactor plant component cooling water is cooled by service water. Thus, two barriers in series, with a radiation alarm in the intervening reactor plant component cooling water, are interposed between potentially radioactive fluids cooled by the reactor plant component cooling water system and the environment. A radiation monitor in the system detects radioactivity in either redundant flow path.

The transfer of supply and return between the reactor plant component cooling water system and the chilled water system is accomplished by the automatic or manual operation of flow diversion valves. Normally, the containment air recirculation coolers, and the on service neutron shield tank cooler are served by the chilled water system. During a loss of power (LOP) or SIS (CIA), the flow diversion valves automatically position themselves to supply reactor plant component cooling water to these components in the chilled water system thereby providing a more reliable source of water for these nonsafety related components inside the containment. Low surge tank level caused by a pipe rupture in the nonsafety related position of the system automatically closes these valves to isolate safety related systems from nonsafety related components.

9.2.2.1.4 Inspection and Testing Requirements

During the life of the unit, all portions of the reactor plant component cooling water system are either in continuous or intermittent operation. Inspections are performed in addition to periodic monitoring of the system parameters during operation.

Class 2 and 3 pumps and valves are tested in accordance with Section 3.9.6 and inspection of Class 2 and 3 portions of this system is performed in accordance with Section 6.6.

9.2.2.1.5 Instrumentation Requirements

Instrumentation and controls are provided for the reactor plant component cooling system to monitor system parameters and alert the operator to any component malfunction. Process variables of components required on a continuous basis for the startup, operation, or shutdown of the unit are controlled, indicated, and alarmed within the control room. Those variables which require minimal operator attention are indicated locally.

Pressure, temperature, and flow indicators are provided in the control room for continuous monitoring of the reactor plant component cooling water system. Low pressure alarms and high flow alarms in the reactor plant component cooling water system are also provided to alert the operator of any major leak in the system.

Redundant pressure sensing instrumentation (surge tank level switches) is designed to detect a sudden drop in reactor plant component cooling water system pressure which would result from a rupture of system piping. This instrumentation automatically initiates closure of valves isolating the safety related piping from the nonsafety related piping and dividing the safety related portion of the system to establish two independent trains.

Redundant reactor plant component cooling supply and return lines serve two residual heat exchangers and two residual heat removal pump seal coolers. Temperature elements are provided in each return line and are monitored by the plant computer. A high and low flow alarm is provided on the main control board for each residual heat exchanger. A low flow alarm is provided on the main control board for each residual heat removal pump seal cooler.

Safety related temperature elements on the RHS heat exchanger cooling water return piping are interlocked with the RHS heat exchanger bypass valves. In the event of excessive CCP piping temperature (155°F) a signal will open the RHS bypass valves fully to preclude heating the CCP return piping above the maximum pipe-stress limit temperature of 160°F.

Low flow in the outlet of the fuel pool coolers is alarmed on the main control board.

Independent identical level sensing channels are provided for each of the two reactor plant component cooling surge tank compartments. The level in the tank is maintained by automatic control of the associated makeup control valve. This valve is opened by a low level switch in either compartment and closed when the level in both compartments exceeds the height of the dividing wall. Water levels for the reactor plant component cooling surge tank compartments are indicated, and extreme limits are alarmed in the control room. Upon receipt of a low level alarm, or indication of a rapidly falling water level, the operator manually closes the air operated valves in the lines of nonsafety related piping as well as the air operated valves dividing the safety related portion in half.

On a DBA the reactor plant component cooling water system valves are automatically positioned as follows:

a. Nonsafety header supply and return isolation valves are closed on receipt of a SIS (CIA) signal except for the cross connect valves to the nonsafety chilled water system which open.

b. On receipt of a CDA (CIB) signal, the containment isolation valves for the reactor plant component cooling water system are automatically closed.

c. On receipt of a CDA (CIB), the reactor plant component cooling heat exchanger service water supply valves are automatically closed (Section 9.2.1.2).

On receipt of a loss of power (LOP) signal, cross connect valves to the chilled water system are opened automatically.

Engineered safety feature status lights are provided on the main control board for the non safety header supply and return valves, for the reactor plant component cooling Train A and B cross connect valves, as well as for the reactor plant component cooling heat exchanger service water supply valves.

Reactor plant component cooling water heat exchanger service water flow is indicated on the main control board, and service water outlet high or low flow is alarmed on the main control board.

Reactor plant component cooling system bypass alarms for Trains A and B are provided on the main control board in accordance with Regulatory Guide 1.47.

9.2.2.2 Chilled Water System

The chilled water system (Figure 9.2–3) is a nonnuclear safety class closed-loop system which provides cooling water for the refueling water storage tank (RWST), service building air-conditioning units, motor control center (MCC) and rod control area air conditioning units, containment air recirculation cooling coils and various components inside the containment structure.

9.2.2.2.1 Design Basis

The chilled water system is nonnuclear safety class with the exception of the containment isolation valves and the piping between them, which are Safety Class 2.

The chilled water system is designed to supply 45°F cooling water for the following functions:

1. Cool the water in the RWST to 75°F or less prior to startup and to maintain a 46°F to 48°F temperature band during normal operation.

2. Supply cooling water for the following air conditioning units:

    a. Service building clean air, air conditioning unit (Section 9.4.11)

    b. Service building potentially contaminated air, air conditioning unit (Section 9.4.11)

    c. MCC and rod control area air conditioning unit (Section 9.4.2) located in the auxiliary building

3. Supply cooling water for the following equipment located inside the containment structure:

   a. Containment air recirculation cooling coils (Section 9.4.6.3)

   b. Reactor coolant pump motor air coolers (Section 5.4.1)

   c. Control rod drive mechanism (CRDM) shroud cooling coils (Section 9.4.6.4)

   d. Neutron shield tank coolers (Section 9.2.2.3)

4. Supply cooling water to the radioactive gaseous waste system process vent cooler

Table 9.2–7 lists these chilled water system heat loads and flow rates for normal plant operation.

9.2.2.2.2 System Description

The system consists of three 50 percent capacity self-contained chiller and circulating pumps, interconnecting piping, valves, and controls. Chiller heat is rejected to the reactor plant component cooling water system. The design data of the major components is shown in Table 9.2–8. The two mechanical refrigeration units and two chilled water circulating pumps provide the capacity to cool components served by the chilled water system. The mechanical refrigeration units are designed to produce a chilled water outlet temperature of 45°F, with a chilled water inlet temperature of 55°F. The third mechanical refrigeration unit and chilled water circulating pump provide a 50 percent standby capacity for the chilled water system. Chilled water system flexibility is provided for by cross-connected piping on the inlet and outlet sides of the mechanical refrigeration units.

The chilled water system is designed as a closed loop system. Variations in volume due to temperature changes are accommodated by the chilled water surge tank, which connects to the chilled water circulating pumps suction header. The chilled water surge tank is pressurized with nitrogen to 7 psig to prevent drain down of system high points and minimize system corrosion. Makeup water for the chilled water system is provided from the reactor plant component cooling water system through an automatic control valve which operates in response to the chilled water surge tank level.

The chilled water system supplies cooling water to two 100 percent capacity refueling water coolers to reduce the RWST temperature to less than 75°F before unit startup and after refueling operation. During normal unit operation, chilled water is supplied to the RWST coolers as necessary, to maintain RWST temperature between 46°F and 48°F. Flow is automatically controlled by a temperature control valve.

The chilled water system supplies chilled water to two 100 percent capacity MCC and rod control area air conditioning units located in the auxiliary building, to maintain proper ambient temperatures. On a loss-of-power (LOP), these units are cooled by the service water system (Section 9.2.1).

The chilled water system supplies cooling water to the potentially contaminated air air-conditioning unit and the clean air, air-conditioning unit, located in the service building, to maintain proper ambient temperatures.

The chilled water system supplies cooling water to three containment air recirculation coolers to maintain proper ambient temperatures inside the containment.

The chilled water system supplies cooling water to two neutron shield tank coolers to maintain proper shield tank temperature.

During a LOP or after receiving a containment isolation Phase A signal (CIA), cooling water supply to two of the three containment air recirculation coolers and the neutron shield tank coolers is transferred to the reactor plant component cooling water system (Section 9.2.2.1). This is accomplished by air-operated (AOV) flow diversion valves, which isolate the chilled water supply to these components and lines up the reactor plant component cooling water system to supply the cooling water necessary.

The chilled water system supplies cooling water to two control rod drive mechanism shroud coolers to cool the control rod drive mechanisms.

The chilled water system supplies cooling water to four reactor coolant pump motor coolers to maintain motor air temperatures within specified conditions.

The chilled water system supplies cooling water to the radioactive gaseous waste process vent cooler, located inside the auxiliary building, to cool the gases prior to their release to the environment.

The containment supply and return chilled water headers are provided with air operated (AOV) containment isolation valves for isolating the containment structure, in accordance with the requirements of the containment isolation system (Section 6.2.4).

Cooling water return lines from each component contain valves for controlling flow. The valves are either manually operated globe type, positioned before unit startup, or air operated, positioned by pressure or temperature control signals originated by the cooled systems.

The two supply and return loop headers inside the containment are cross-connected to provide balanced flow under various equipment operation modes. Three pairs of closely coupled block valves divide each loop into quadrants. These valves allow any quadrant to be isolated while the remainder of the loop is maintained in service. Because the supply loop has two independent supplies of cooling water, continued unit operation is assured at reduced load during maintenance of a single component.

Thermal relief valves are provided on all equipment which might be overpressurized during equipment isolation with continued heat input.

9.2.2.2.3 Safety Evaluation

This system is not safety related; therefore, no safety evaluation is provided. A design evaluation has been performed to demonstrate the system capability to perform its intended function.

The chilled water system uses equipment and components of proven, conventional design. All components are specified to provide maximum safety and reliability.

Low pressure, high temperature, or mechanical refrigeration unit trouble alarms will signal the operators' attention to malfunctions. If the malfunction causing the alarm is not corrected, components and systems served by the chilled water subsystem may be inadequately cooled, requiring the operator to shut down affected components to prevent damage. Cooling of critical components inside the containment structure may be transferred to the reactor plant component cooling water system.

The chilled water system does not normally contain radioactive water; however, provisions are made to preclude the spread of radioactive contamination in the event of a leak into the chilled water system. Such provisions include the ability to isolate any heat exchanger served by the system. In addition, welded construction is used whenever possible to minimize the possibility of leakage from piping, valves, and fittings.

During normal operation, two mechanical refrigeration units and two chilled water circulating pumps accommodate the heat removal load. The third mechanical refrigeration unit and chilled water circulating pump provides 50 percent spare capacity. Two full capacity refueling water coolers and two MCC and rod control area air conditioning units provide a 100 percent spare capacity. The single chilled water supply and return line for the refueling water coolers can be serviced while the RWST water temperature is at or below its design temperature due to the low heatup rate of the large insulated tank.

With the installed 50 percent spare capacity, maintenance of major components can be accomplished without loss of chilled water supply.

Two of the three containment air recirculation cooling coils and both of the neutron shield tank coolers located inside the containment structure and served by the chilled water system are cooled by the reactor plant component cooling water system when off site power is not available (LOP) or upon receipt of a CIA signal. Air-operated flow diversion valves are used to transfer both the supply and return water headers connecting these components inside the containment structure to the reactor plant component cooling water system (Section 9.2.2.1).

9.2.2.2.4 Inspection and Testing Requirements

Since the chilled water system is in continuous operation during normal plant operation, performance tests are not required. During refueling shutdown, this system may run only intermittently and the equipment is tested periodically. Standby mechanical refrigeration equipment and pumps are rotated in service on a scheduled basis. All components are accessible for visual inspections, which are conducted periodically and following installation of repair parts or modifications, to confirm normal operation of the system. Routine prestartup inspections are performed in addition to periodic observation and monitoring of system parameters during operation.

Containment isolation valves are tested and inspected in accordance with Section 6.2.4.4.

9.2.2.2.5 Instrumentation Requirements

The chilled water system operating parameters are monitored, indicated, and controlled locally or remotely as follows. Unless stated otherwise, the following controls are on the main control board:

1. Control switches with indicator lights for manual operation of the chilled water circulating pumps.

2. The mechanical refrigeration units have control switches and indicator lights at the main control board and locally to start or stop the units.

3. Chilled water containment isolation valves have control switches and indicator lights. A CIA signal automatically closes the valves.

4. Containment air recirculation coil isolation valves have control switches and indicator lights. The valves are automatically closed by a CIA or LOP signal.

5. The refueling water coolers temperature control valve has a control switch with indicator lights. The valve can be closed and opened manually or automatically. When in automatic, the valve opens when the refueling water storage tank temperature is greater than 48°F and closes when the refueling water storage tank and recirculating pump suction temperature is less than 46°F.

6. The chilled water surge tank makeup valve can be opened or closed by a control switch with indicating lights. The valve can also be controlled automatically. When in automatic control the valve is opened and closed by a surge tank level switch.

7. A flow indicating controller with automatic/manual control is utilized to modulate the refrigeration unit recirculation flow valve. The input flow signal to the controller is the summation of outlet flow from the three chillers.

Annunciators are provided to alarm when the following conditions exist:

1. Chilled water circulating pump motor auto trip/overcurrent

2. Evaporator outlet temperature high/circulation water flow low
3. Chilled water supply pressure low
4. Chiller outlet flow high/chiller recirculation flow high
5. Bus load control power not available
6. Mechanical refrigeration unit motor auto trip/overcurrent
7. Refueling water coolers outlet flow low
8. Chilled water surge tank level high/low
9. Containment air recirculation cooling coil flow low

Engineered Safety feature status lights indicate the following:

1. Chilled water containment isolation valves closed
2. Containment air recirculation coil isolation valves closed

Indicators are provided to monitor the following parameters:

1. Chilled water circulation pump motor amperage
2. Chiller recirculation flow
3. Mechanical refrigeration unit motor amperage

The following parameters are monitored by the plant computer:

1. Chilled water circulating pump motor overcurrent
2. Chilled water circulating pump auto trip
3. Chilled water circulating pump breaker position
4. Mechanical refrigeration unit auto trip
5. Mechanical refrigeration unit breaker position
6. Mechanical refrigeration unit overcurrent
7. Chilled water containment isolation valves open

8. Chilled water containment isolation valves closed

9. Neutron shield tank cooler outlet temperature greater than a predetermined set point

10. Containment air recirculation coil isolation valves open

11. Containment air recirculation coil isolation valves closed

12. Chiller motor thrust bearing temperature

13. Chiller motor radial bearing temperature

Indicating lights are provided at the switchgear for the following units:

1. Chilled water circulating pump

2. Mechanical refrigeration unit

Indicators are provided at the switchgear for the following:

1. Chilled water circulating pump amperage

2. Mechanical refrigeration unit amperage

The following controls are located locally:

1. An ON-OFF control switch for the refrigeration transfer unit

2. Start/STOP-RESET pushbutton with indicating lights for the mechanical refrigeration unit

3. OPEN-HOLD-CLOSE-AUTO control switch for the mechanical refrigeration unit suction inlet guide vanes

4. 40-60-80-100 percent position switch for the mechanical unit electrical capacity demand

5. RAISE-LOWER control switch for the mechanical refrigeration unit chilled water temperature

6. SERVICE-NORMAL control switch for the mechanical refrigeration unit lube oil pump

7. AUTO-MANUAL control switch with running indicating light for the mechanical refrigeration unit lube oil pump

8. ON-OFF control switch with an indicating light (energized) for the mechanical refrigeration unit panel heater

9. Temperature controller with auto/manual feature and indication for the mechanical refrigeration unit condenser component cooling water supply valve

Local indicating lights are provided for the following:

1. Mechanical refrigeration unit anti-recycling

2. Mechanical refrigeration unit oil heater on

3. Loss of power

4. Lube oil pressure low

5. Freon discharge pressure high

6. Freon suction pressure low

7. Chilled water temperature low

8. Lube oil, mechanical refrigeration unit motor or freon discharge temperature high

9.2.2.3 Neutron Shield Tank Cooling System

The neutron shield tank cooling system is shown on Figure 9.2–4.

9.2.2.3.1 Design Bases

The neutron shield tank cooling system cools the water circulated through the neutron shield tank which is heated by the surrounding components, structures and environment, including neutron and gamma radiation from the reactor. The neutron shield tank cooling system is not safety related and, therefore, is not designed to Seismic Category I requirements, and need not meet the single failure criterion.

9.2.2.3.2 System Description

Neutron shield tank cooling system components are summarized in Table 9.2–9. Two 100 percent capacity neutron shield tank coolers, a neutron shield tank surge tank, and necessary piping and valves constitute the system. The neutron shield tank cooling system is designed as a natural circulation system, thus, pumps are not required.

The heated water in the neutron shield tank rises to the top of the tank and exits into the pipe leading to the neutron shield tank coolers. Cool water from the chilled water system (Section 9.2.2.2) is circulated through the shell side of the neutron shield tank coolers, cooling the heated neutron shield tank water which flows through the tube side by natural convection circulation.

One 100 percent capacity neutron shield tank cooler performs the required cooling. The second 100 percent capacity cooler is a spare. The second 100 percent capacity cooler is a spare, but can be used in parallel with the other cooler in the event additional cooling is desired to operate the shield tank at minimum temperatures. The neutron shield tank surge tank accommodates thermal expansion of the neutron shield tank water. Primary grade water supplies makeup water to the neutron shield tank surge tank.

Corrosion inhibiting chemicals are added to the neutron shield tank cooling water via the neutron shield tank surge tank.

9.2.2.3.3 Safety Evaluation

The two 100 percent capacity neutron shield tank coolers provide redundancy and reserve cooling capacity. Manual block valves are provided at the inlet and outlet lines of each cooler and enable either cooler to be isolated, if required. The neutron shield tank cooling system uses equipment and components of proven, conventional design.

9.2.2.3.4 Inspection and Testing Requirements

A hydrostatic test was conducted following construction. Specific performance tests are not required because the neutron shield tank cooling system is in continuous operation and is monitored in the control room (Section 9.2.2.3.5). Periodic analysis of the monitored parameters will reveal possible degradation of the system's performance. The neutron shield tank coolers are alternated in service on a scheduled basis. The neutron shield coolers are alternated in service on a scheduled basis, when single cooler operation is desired. Both shield tank coolers can be placed in service simultaneously when reserve cooling capacity is desired. All system components are accessible for visual inspections. Routine prestartup inspections are made along with periodic observation and monitoring of the system during operation.

9.2.2.3.5 Instrumentation Requirements

The neutron shield tank cooling system is monitored, indicated, and controlled, locally or remotely, as follows:

1. Level sensing instrumentation of the neutron shield tank surge tank indicates and alarms in the control room for low and high tank levels. The system water inventory is controlled by makeup from the primary grade water system and letdown to aerated drains. The makeup initiation is remote-manual from the control room and follows a low level alarm.

2. Shield tank cooling water inlet and outlet temperature and the differential temperature is monitored by the plant computer. High neutron shield tank coolant temperature is alarmed in the control room.

9.2.2.4 Charging Pumps Cooling System

The charging pumps cooling system (Figure 9.2–5) cools the oil for the charging pumps.

9.2.2.4.1 Design Bases

The charging pump cooling system transfers heat load from the charging pumps lubrication oil to the service water system. The system is designated Safety Class 3, Seismic Category I, and mechanical components are designed to ASME III, Class 3 requirements. Class IE electrical components are qualified to IEEE-323 as described in Section 3.11. The system is designed to meet the requirements of the single failure criteria.

9.2.2.4.2 System Description

Two 100 percent capacity charging pumps cooling pumps, two 100 percent capacity charging pumps coolers, and a charging pumps cooling surge tank constitute major equipment in the system. The system supplies 15 to 16.5 gpm of cooling water to the charging pumps oil coolers (one cooler per charging pump) to remove 81,000 Btu/hr per charging pump. Table 9.2–10 lists other design parameters.

Either of the two charging pumps cooling pump circulates cooling water to the tube side of the charging pumps oil cooler of the operating charging pump, where heat is absorbed from the oil. Cooling water is also circulated to the oil cooler of the standby charging pump, which is connected to the emergency bus. The third charging pump is normally electrically disconnected from the emergency bus, and the charging pumps cooling piping to this pump is normally valved closed. Valving to the standby charging pump cooler is aligned for normal operation. If the standby charging pump starts (automatically) during normal operation, cooling water is already supplied to its oil cooler. The warmed system water returns from the charging pumps cooling pump oil cooler and then passes through the shell side of the associated charging pumps cooler. The heat is transferred to the service water system (Section 9.2.1) via these coolers.

In the event that the operating charging pumps cooling pump fails during normal operation, a pressure switch located on the pump discharge piping automatically starts the other charging pumps cooling pump. In the event of the SIS or loss of power signal, the second charging pumps cooling pump will automatically start, and the redundant cross-connection valves in the suction and discharge lines of the cooling pumps will close.

Automatic isolation of the two charging pumps cooling flow paths will allow the cooling pump of each charging pump to provide cooling water independently to its respective charging pump.

The charging pumps cooling system is designed as a closed system. Variations in volume due to temperature changes are accommodated by the charging pumps surge tank, connected to the charging pumps cooling pumps suction. The charging pumps cooling surge tank is the high point of the system and provides the net positive suction head (NPSH) for the charging pumps cooling pumps. Charging pumps cooling system makeup is supplied from a safety related portion of the reactor plant component cooling water system, through an automatic control valve which operates in response to either of two level signals from the charging pumps cooling surge tank compartments. This surge tank is compartmented by an internal partition so that a rapid loss of water from one compartment of the surge tank affects only one charging pumps cooling pump, leaving the other charging pumps cooling pump unaffected and fully capable of service. The internal partition is open at the top to allow pressure equalization between compartments. System makeup is assured by sizing the surge tank at 500 gallon per redundant system to accommodate a 30-day period without refill and by providing a safety related makeup source from the reactor plant component cooling water system (Section 9.2.2.1). The charging pumps cooling system piping is a 150 psi, ANSI rated carbon steel system.

The charging pumps cooling pumps are powered from separate emergency buses. Separation of electrical components onto two emergency buses ensures that a failure of one bus does not interfere with the function of the redundant system.

9.2.2.4.3 Safety Evaluation

Redundant components and piping are used throughout the charging pumps cooling system. The charging pumps cooling pumps are powered from redundant emergency buses. The use of redundant components, piping, and emergency buses ensures that the system can withstand a single failure.

One charging pumps cooling pump and both charging pumps coolers are normally in service to supply the operating and standby charging pumps oil coolers. The line supplying cooling water to the third charging pump oil cooler is normally separated by closed isolation valves. The discharge lines of the two charging pumps cooling pumps are connected by a crossover line having two air-operated trip valves which are normally open. The suction lines of the two charging pumps cooling pumps are similarly connected by a crossover line containing two air-operated trip valves which are normally open. Thus, one charging pumps cooling pump cools both charging pumps coolers. In the event of an SIS, the trip valves are closed automatically to isolate redundant cooling paths, and the second charging pumps cooling pump starts. A single failure of any component in either cooling loop does not affect operation of the redundant train.

To ensure that service water is continuously available, the charging pumps coolers are connected to separate service water supply and return lines.

The header supplying cooling water to the charging pumps oil coolers is connected through valving to each charging pumps cooling pump. The cooling water supply and discharge headers have isolation valves to allow the charging pumps oil coolers corresponding to any two of the three charging pumps to be separated from the third charging pump oil cooler. The operating and standby charging pump oil coolers are fed through separate flow paths during normal operation. The third charging pump oil cooler remains isolated during normal operation. Failure of one charging pumps cooling pump actuates a low pressure switch which automatically starts the standby charging pumps cooling pump. Should the standby charging pump be required to operate, adequate oil cooling capacity is available for two charging pumps with one charging pumps cooling pump operating. Under accident conditions, the charging pumps cooling pumps supply and return headers are automatically separated for redundancy.

Surge tank low level alarms as well as building sumps with high level alarms are provided to detect component or system leakage, thus permitting the operator to take appropriate action to avoid system operational degradation.

A malfunction analysis, giving consequences of component failure, is given in Table 9.2–11.

A tornado will have no effect on the charging pumps cooling system because the equipment is located inside the tornado protected auxiliary building. This system is designed to Seismic Category I requirements and will, therefore, be operable in the event of a safe shutdown earthquake.

This system is located above the flood level in the flood protected auxiliary building and thus is not affected by floods.

The charging pumps cooling system will not cause any radioactivity to be released to the environment because it does not cool any potentially radioactive fluid. Analysis of postulated cracks in moderate energy piping is discussed in Section 3.6.

9.2.2.4.4 Inspection and Testing Requirements

The charging pumps cooling system is in continuous operation, with essential system parameters (system temperatures, pressures, and flow capacity) continuously monitored and indicated in the control room by instrumentation. Performance tests are, therefore, not required. The charging pumps cooling pumps are alternated in service on a scheduled basis. All components are accessible for in service inspections. In service Testing per ASME code for Operation and Maintenance of Nuclear Power Plants requirements are performed for each pump on a scheduled basis.

Class 2 and 3 pumps and valves are tested in accordance with Section 3.9.6 and inspection of Class 2 and 3 portions of this system is performed in accordance with Section 6.6.

9.2.2.4.5 Instrumentation Requirements

The charging pumps cooling system operating parameters are monitored, indicated, and controlled locally or remotely. The charging pumps cooling pumps and valves are controlled from the main board in the control room. The instrumentation provisions follow.

Annunciators are provided on the main board for the following:

1. Charging pumps coolers outlet temperature, Low

2. Charging pumps surge tank level, High

3. Charging pumps surge tank level, Low

4. Charging pumps oil coolers outlet temperature, High

5. Charging pumps oil coolers flow, Low

6. Engineered safety features status lights are provided on the main control board to indicate that the charging pump cooling pump has started and that the charging pump coolers outlet crossover valves are shut.

Computer inputs are provided for the following system parameters:

1. Charging pumps cooling pumps started

2. Charging pumps cooling pump discharge pressure

3. Charging pumps cooling pump suction pressure

4. (Deleted)

5. (Deleted)

6. Charging pumps cooling pump bearing temperature

7. Valve position of the charging pump coolers outlet crossover valve

8. Charging pumps oil cooler flow

Local temperature indicators are provided on the inlet and outlet to the charging pump coolers. Local level indicators are provided for the charging pumps cooling surge tank as well as a local flow totalizer for inlet flow to the surge tank. Local temperature indicators are provided on the outlet of the charging pump oil coolers.

A “PULL-TO-LOCK” feature is incorporated in the charging pump cooling pump control switch, which when activated, actuates a bypass status annunciator in compliance with Regulatory Guide 1.47.

9.2.2.5 Safety Injection Pumps Cooling System

The safety injection pumps (Figure 9.2–4) cools the bearing oil for the safety injection pumps.

9.2.2.5.1 Design Bases

The safety injection pumps cooling system transfers heat load from the safety injection pumps bearing oil to the service water system. The system is designated Safety Class 3, Seismic Category I, and mechanical components are designed to ASME III, Class 3 requirements. Class IE electrical components are qualified to IEEE-323 as described in Section 3.11. The system is designed to meet the requirements of the single failure criteria.

9.2.2.5.2 System Description

Two 100 percent capacity safety injection pumps cooling pumps, two 100 percent capacity safety injection pumps coolers, and a safety injection pumps cooling surge tank constitute major equipment in the system. The system supplies 10 gpm cooling water to the safety injection pumps bearing oil coolers (one bearing oil cooler for each safety injection pump) to remove 27,900 Btu/hr. Table 9.2–12 lists other design parameters.

The safety injection pumps cooling system is not normally in operation, but automatically initiates upon start of the associated safety injection pump. When required to run, each safety injection pumps cooling pump circulates cooling water to the oil cooler of its associated safety injection pump, where heat is absorbed from the pump bearing oil. The warmed system water returns from the safety injection pump bearing oil cooler through the safety injection pump cooler where heat is transferred to the service water system (Section 9.2.1).

The safety injection pumps cooling system is designed as a closed system. Variations in volume due to temperature changes are accommodated by the safety injection pumps surge tank connected to the safety injection pumps cooling pump suctions. The safety injection pumps surge tank is the high point of the system and provides the net positive suction head (NPSH) for the safety injection pumps cooling pumps. The surge tank is compartmented by an internal partition so that a rapid loss of water from one compartment of the surge tank affects only one safety injection pumps cooling pump, leaving the other safety injection pumps cooling pump unaffected and fully capable of service. The internal partition is open at the top to allow pressure equalization between compartments. Safety injection pumps cooling system makeup is supplied from a safety related portion of the reactor plant component cooling water system, through an automatic control valve which operates in response to either safety injection pump cooling surge tank compartment level. System makeup is assured by sizing the surge tank at 500 gallons per redundant system to accommodate a 30 day period without refill and by providing a safety related makeup source from the reactor plant component cooling water system (Section 9.2.2.1).

The safety injection pumps cooling subsystem piping is a 150 lb ANSI rated carbon steel system.

The safety injection pumps cooling system is designed with redundant, independent, cooling circuits. Separation of electrical components onto two emergency buses ensures that a failure of one bus does not interfere with the function of the redundant system.

9.2.2.5.3 Safety Evaluation

Redundant components and piping are used throughout the safety injection pumps cooling system. Each safety injection pumps cooling pump is powered from the same emergency bus as its associated safety injection pump. The use of redundant components, piping, and emergency buses ensures that the system can withstand a single failure.

The safety injection pump cooling pump, serving one safety injection pump, starts whenever its respective safety injection pump is started. The second safety injection pump cooling pump is associated with the redundant safety injection pump and provides the required redundancy. The system has two independent coolant loops, each of 100 percent capacity. Failure of one loop does not affect the operation of the other loop, and the system may continue in operation.

Surge tank low level alarms as well as sumps with high level alarms are provided to detect component or system leakage, thus permitting the operator to take appropriate action to avoid system operational degradation.

To ensure that service water is continuously available, a separate service water supply and a separate service water return line are connected to each of the safety injection pumps coolers. A malfunction analysis, giving consequences of component failure, is given in Table 9.2–13.

A tornado will have no effect on the safety injection pumps cooling system because the equipment is located inside the tornado-protected engineered safety features building. The system is designed to Seismic Category I requirements and will, therefore, be operable in the event of a safe shutdown earthquake.

The safety injection pumps cooling system does not cause any radioactivity to be released to the environment because it does not cool any potentially radioactive fluids. Analysis of postulated cracks in moderate energy piping is discussed in Section 3.6.

9.2.2.5.4 Testing and Inspections

Both safety injection pumps cooling loops are periodically operated with essential system parameters being monitored and indicated in the control room by instrumentation. All components are accessible for inservice inspections.

Class 2 and 3 pumps and valves are tested in accordance with Section 3.9.6 and inspection of Class 2 and 3 portions of this system is performed in accordance with Section 6.6.

9.2.2.5.5 Instrumentation Requirements

The safety injection pump cooling system operating parameters are monitored, indicated, and controlled locally or remotely.

The safety injection pump cooling pumps and makeup water valve are controlled from the main board in the control room. The cooling pumps are controlled with a STOP-AUTO-START switch with indicating lights and the safety injection pumps cooling surge tank makeup valve is operated by a CLOSE AUTO OPEN switch with indicating lights.

Annunciators are provided for safety injection pump cooling water flow low, for safety injection pump surge tank level high or low, for safety injection pump oil cooler outlet temperature high and for MCC power not available. Status lights are provided for MCC load control power not available on rear of main control board.

Engineered-safety-features status lights are provided to indicate when the safety injection pump cooling pumps are running.

Computer inputs are provided for the following system parameters:

1. Safety injection pump cooling pump thrust bearing temperature
2. Safety injection pump cooling pump bearing temperature
3. Safety injection pump cooling pump breaker position
4. Safety injection pump cooling pump discharge pressure
5. Safety injection pump cooling pump suction pressure
6. Safety injection pump oil coolers flow
7. (Deleted)
8. (Deleted)
9. (Deleted)

Local temperature indicators are provided on the inlet and outlet of the safety injection pump coolers. Local level indicators are provided for the surge tanks and local temperature indicators are provided for the lubricating oil outlet of the safety injection pump bearing oil coolers.

9.2.2.6 Condensate Demineralizer Component Cooling Water System (Removed from Service)

The condensate demineralizer component cooling water system (Figure 9.2–6), cooled by the screen wash disposal system, was designed to supply cooling water to various components in the regenerant liquid waste and auxiliary condensate systems. The condensate demineralizer component cooling water system is not safety related and is removed from service.

9.2.2.6.1 Design Bases

The condensate demineralizer component cooling water system was designed to provide cooling water to the following components (which were removed from service):

1. Regenerant distillate cooler (Section 11.2)
2. Regenerant evaporator condenser (Section 11.2)
3. Regenerant evaporator bottoms cooler (Section 11.2)
4. Regenerant evaporator bottoms sample cooler (Section 11.2)
5. Auxiliary condensate sample cooler (Section 10.4.10)

Table 9.2–14 gives the design data for each of these components.

The Millstone 3 condensate demineralizer component cooling water system (3CCD) is isolated from the Millstone 2 condensate demineralizer component cooling water system (2CCD).

9.2.2.6.2 System Description

This system has been removed from service and is isolated from the plant.

9.2.2.6.3 Safety Evaluation

The condensate demineralizer component cooling water system (removed from service) is not safety related; therefore, it is not seismically designed and is not designed to withstand a single failure. Failure of any portion or component of this system will not damage any safety related component or system.

9.2.2.6.4 Inspections and Testing Requirements

This system is removed from service and is isolated from the plant. No further testing is required.

9.2.2.6.5 Instrumentation Requirements

The condensate demineralizer component cooling system is removed from service and is administratively controlled by operations.

9.2.3 DEMINERALIZED WATER MAKEUP SYSTEM

The demineralized water makeup (WTS) systems (Figure 9.2–7) include the supply water treating system, the wastewater treating system and the common makeup water treatment system. None of these systems is safety related.

9.2.3.1 Design Bases

The function of the common makeup water treatment system is to provide makeup demineralized-deaerated water for Millstone Unit 2 and Unit 3 nuclear steam supply systems (NSSS) and their auxiliary systems, and to provide demineralized makeup water to Millstone Unit 2 and Unit 3 secondary systems.

The following criteria have been used in the design of the common water treatment system:

a. The CWTF makeup water demineralizer section of the water treatment system shall provide up to 400 gpm to meet the demands of Units 1, 2 and 3.

b. The water treatment system shall be designed to permit periodic inspection of important components such as pumps, demineralizers, tanks, filters, valves and piping to ensure the integrity and capability of the system.

c. The water treatment components shall be designed to operate within the environment to which they are exposed.

d. The system has automatic and manual control for operation.

e. The conductivity of product water is designed to be less than 0.1 micromhho/cm.

f. The CWTF is designed as a non-safety related system. It is not designed to seismic Category I requirements.

The wastewater treating system is designed to accept the wastes from two back-to-back regenerations of one demineralizer train in the water treating system.

It is not necessary for the wastewater treating system to be operated continuously, because storage capacities adequate for normal usage are provided. Redundancy of all equipment in the water treating system is not required; however, two full sized trains of basic water treating equipment are provided to permit uninterrupted operation during demineralizer regeneration and pump maintenance.

9.2.3.2 System Description

Domestic (city) water is supplied to the Common Water Treatment Facility through a back flow prevention valve to prevent chemical contamination of the domestic water supply. The Common Water Treatment Facility is sized to provide the makeup water requirements for Millstone Units 1, 2, and 3. The Common Water Treatment Facility supplies deaerated water to the Unit 2 Condensate Storage Tank (CST) via the separate eight inch supply header and to all other tanks in Units 2 and 3 via the cross tie header.

If the makeup water requirement exceeds the normal operating flow rates for either unit, such as during chemistry holds during startup, the Common Water Treatment Facility has the flexibility to divert the additional water as needed.

The design chemical analysis of demineralized water from the vendor water treatment system is as follows:

Silica, max (ppb)	10
Conductivity, max (μmhos/cm)	0.1
Dissolved oxygen, max (ppm)	0.1
Sodium, max (ppb)	1
Chloride, max (ppb)	1
Sulfate, max (ppb)	2
Calcium, max (ppb)	2
Magnesium, max (ppb)	2
Aluminum, max (ppb)	10
Total organic carbon (ppb)	50

The following sections describe the ultrafiltration system. This system is not in use.

Either of the two full capacity ultrafiltration supply pumps draws water from the water treating storage tank and pumps the water through common discharge piping to either of two trains of ultrafiltration equipment. Each of the two parallel trains provided includes one ultra filtration booster pump and one ultrafiltration module rack. This rack, consisting of mounted membrane cartridges, removes any suspended solids or large organic molecules which may be present. An ultrafiltration permeate tank, common to both trains, is used to store product water and to provide common suction to the Contract Water Treatment Facility (CWTF) supply pumps. Permeate is also used to dilute a solution which cleanses the ultrafiltration membranes on a periodic basis.

A pH adjustment/chemical feed tank and two full capacity chemical metering pumps to add chemicals to the common supply line leading to both ultrafiltration trains are provided. Chemicals which may be added include caustic for pH adjustment or a dispersant. This chemical addition, if required, will ensure that dissolved silica which remains in solution will not foul the membranes.

Cleaning of the ultrafiltration membrane cartridges is done automatically based on a preset pressure drop across the unit. A dedicated UF supply pump provides flow required for the two high shear steps of the cleaning cycle. The membranes are backflushed using water from the permeate tank supplied by one of two full capacity ultrafiltration flush pumps. A cleaning solution (sodium hypochlorite) is added during the backflush step. One cleaning solution tank and two full capacity chemical metering pumps to add sodium hypochlorite solution to the suction line of the ultrafiltration booster pumps are provided.

Cleaning of the ultrafiltration membrane cartridges (one train) is automatic, based on a preset pressure drop across the unit and consists of the following six steps:

1. 4 minute high shear sweep of the fiber Walls:

   Flow supplied by the UF supply pumps is 600 gpm.

2. 4 minute permeate backflush with the addition of a NaOCl concentrate:

   Flow supplied by the UF flush pumps is 131 gpm. Flow supplied by the cleaning solution pumps is variable.

3. 8 minute pause.

4. 4 minute backflush rinse:

   Flow supplied by the UF flush pumps is 131 gpm.

5. 4 minute high shear sweep of the fiber walls:

   Flow supplied by the UF supply pumps is 600 gpm.

6. 2 minute flush:

Flow supplied by the UF supply pumps is 131 gpm.

Backflushing involves closing of the feedwater and permeate valves, and opening the ends of the cartridges to drain. The ultrafiltration flush pump supplies water which was stored in the permeate storage tank to the permeate side of the hollow fiber cartridges. The water (under pressure) flows inward through the fiber walls, losing accumulated debris and carrying it out both ends of the fiber tubes to drain. The NaOCl solution is added by means of a chemical metering pump only during the backflush portion of the cleaning sequence. The chemical pump is operated for 4 minutes during the backflush step. After the chemical addition, the cleaning sequence provides an 8-minute pause followed by a 4 minute flush to waste using the UF flush pumps. Following the second high shear sweep, the system is flushed as in normal operation for 2 minutes to drain before the permeate is sent to the permeate tank.

The ultrafiltration equipment is designed to allow one train to operate in the process cycle while the alternate train is in the backflush pause, backflush rinse, or flush steps of the cleaning cycle. The alternate train is shut down during the two high shear steps.

The WTS has not been used since plant startup. The following WTS descriptions are for historical purposes.

The carbon filter must occasionally be removed from service and washed to loosen the carbon bed and to remove collected solids from the surface of the bed. Carbon filter washing is operator initiated and consists of a timed backwash step and a timed rinse step. Water used for both steps is drawn from the permeate tank by the makeup demineralizer supply pumps and directed to the waste regenerant neutralizing sump.

The cation, anion, and mixed bed vessels are a source of demineralized water as long as the total gallons throughout has not been exceeded as set on the water meters, or the water quality has not exceeded the conductivity setpoints. When either of the above conditions has been exceeded, operating personnel must initiate regeneration of the demineralizers. Once initiated, the sequencing is controlled by timers.

Acid and caustic solutions regenerate exhausted resin beds. Concentrated acid and caustic are kept in storage tanks and chemical transfer pumps pump the acid and caustic, as required, to chemical measuring tanks. Acid and caustic metering pumps supply the chemicals through mixing tees (where they are diluted) to the appropriate demineralizer beds during regeneration.

To regenerate the cation bed, sulfuric acid, diluted with (carbon) filtered water, is added stepwise to convert all cation resin to the hydrogen form. Before and after the acid addition, the cation bed is backwashed with (carbon) filtered water to remove accumulated crud and residual acid.

To regenerate the anion bed, caustic, diluted with condensate makeup and drawoff water, is added to convert all anion resin to the hydroxide form. Before the caustic addition, the anion bed is backwashed with (carbon) filtered and (cation) demineralized water to remove accumulated crud and after regeneration it is rinsed to remove residual caustic.

To regenerate the mixed bed, anion and cation resins are separated by backwashing, followed by addition of caustic to convert anion resin to the hydroxide form and addition of acid to convert cation resin to the hydrogen form. Both acid and caustic are diluted with the condensate makeup and drawoff water. A series of rinsing steps with (carbon) filtered and demineralized water is used to purge residual caustic from the anion resin and residual acid from the cation resin. Finally, the resins are remixed.

The wastewater treating system (Figure 9.2–7) treats all wastes from the water treating system, including spent acid and caustic and ultrafiltration cleaning wastes, which drain to an 83,000 gallon waste neutralization sump. Here, they are batch neutralized and discharged into the circulating water discharge tunnel. Acid and caustic metering pumps draw acid and caustic from the chemical measuring tanks and supply these chemicals to the sump as required for neutralization. A pH indicator, located on the waste sump recirculation line, is used by operating personnel to determine either the need for further neutralization or the need to direct flow to the circulating water discharge tunnel.

The demineralized effluent from the CWTF flows, when required, to the 300,000 gallon capacity condensate storage tank (Section 9.2.6), to the 150,000 gallon condensate surge tank (Section 9.2.6), or to the two 100,000-gallon capacity primary grade water storage tanks (Section 9.2.8) and to the 360,000 gallon capacity demineralized water storage tank (Section 10.4.9).

During periods when demineralized water is not required, a minimum flow can be recirculated through the demineralizer water treating supply pump suction.

The source of raw water for this system is the Town of Waterford Public Water Supply, which is of potable quality. This water is stored in the water treating storage tank which has a capacity of approximately 35,000 gallons. To prevent any possible contamination of the Town of Waterford Public Water Supply from backflow of the water treating system, the piping upstream of the public water storage tank has an air-break. Table 9.2–15 presents the design data for the major components.

9.2.3.3 Safety Evaluation

These systems are not safety related. Failure of any portion or component of these systems will not damage any safety related component or system. The following design evaluation is provided to demonstrate the system’s capability to perform its intended function.

The water treating system and the storage tanks are of sufficient capacity to meet demineralized and primary grade water requirements for preoperational cleaning, unit startup, and continuous unit operation, including periods of demineralizer regeneration and routine maintenance.

The reduced flow recirculation enables the demineralizer to be in constant readiness for unit makeup demand.

The system is designed to meet NRC Branch Technical Positions ASB 3 1 and MEB 3 1 (Section 3.6) as related to breaks in high and moderate energy piping systems outside containment.

9.2.3.4 Inspection and Testing Requirements

The entire water treating system is used regularly, on a day-to-day basis, either in the production of demineralized water or in the process of demineralizer regeneration. Therefore, the operability of the system is regularly demonstrated, and periodic testing to ensure that operability is not required.

Performance of the demineralizer's components can be tested to determine compliance with the effluent water quality requirements using test methods published in ASTM Standards, Part 23 - Industrial Water: Atmospheric Analysis, latest edition.

System equipment is tested for leakage and proper automatic control action prior to initial operation. The flow and conductivity of the demineralizer train effluent are continuously monitored during normal operation. Samples from the various storage tanks are periodically taken and tested.

9.2.3.5 Instrumentation Requirements

The ultrafiltration permeate line flow indicating transmitter, recorder, and totalizer are provided for the ultrafiltration permeate.

A flow control device is provided at the discharge of the ultrafiltration supply pumps to maintain the required water flow to the ultrafiltration booster pumps. A pressure control device is provided at the discharge of the ultrafiltration booster pumps to maintain water pressure to the ultrafiltration module bank at the desired setting.

The ultrafiltration module bank is cleaned automatically, as required, using both raw water and water from the ultrafiltration permeate tank. The permeate tank is sized to store sufficient water for cleaning and for supplying water to the demineralizers during cleaning of the ultrafiltration modules.

A pressure control device is provided at the discharge of the water treating supply pumps to maintain the water pressure at the inlet to the carbon filters at the desired setting.

The makeup to the condensate storage tank is manually controlled. The air-operated makeup valve receives a close signal upon tank high level. The makeup to the condensate surge tank is manually controlled. The air-operated makeup valve receives a close signal upon tank high level. The makeup to the demineralized water storage tank is under administrative control.

A level controller in the water treating storage tank modulates a control valve in the public water supply line to maintain tank water level.

9.2.4 DOMESTIC AND SANITARY WATER SYSTEMS

The potable and sanitary water systems (Figure 9.2–8) are not safety related.

9.2.4.1 Design Bases

The domestic water system (Figure 9.2–8) is designed to supply and distribute cold and hot water throughout the unit for sanitary purposes, supply cold water throughout the plant for washdown and general maintenance through sillcocks, and supply, makeup or cooling water to selected systems. The domestic water system employs backflow preventers, air gaps, and vacuum breakers throughout the system to prevent any possible contamination of the system. Contamination sources can be from radioactive, chlorine, or other flushing activities conducted on systems throughout the plant.

The sanitary system collects drainage from sanitary components and directs noncontaminated drainage to the Town of Waterford Sewer System. The sanitary system directs potentially contaminated drainage to a contaminated sump for further transfer to the radioactive liquid waste system.

9.2.4.2 System Description

The domestic water system is fed from the Town of Waterford public water supply. A branch line from the extension of the Town of Waterford public water supply is sized to carry a maximum of 240 gpm to the water treating storage tank of the water treating system and a maximum of 240 gpm to the domestic water system.

Domestic water is supplied for the following nonsanitary purposes:

1. Makeup to control building chilled water (Section 9.4.0). Protection from reverse flow is provided by an air gap.

2. Trap seals for the control building mechanical equipment room floor drains. Protection from reverse flow is provided by an air gap.

3. Trap seals for the main steam valve building floor drains. Protection from reverse flow is provided by an air gap.

4. Trap seals for the turbine building ventilation vent. Protection from reverse flow is provided by an air gap.

5. Seal water to the vacuum priming pumps (Section 10.4.5). Protection from reverse flow is provided by a backflow preventer.

6. Seal water to the Unit 2 and 3 condensate demineralizer rotary air blowers (2CND-FN1 and 3CND-FN1). Protection from reverse flow is provided by backflow preventers.

7. Makeup water to the water treating storage tank (Section 9.2.3). Protection from reverse flow is provided by an air gap.

8. Emergency cooling water to the instrument air compressors (Section 9.3.1.1). Protection from reverse flow is provided by a backflow preventer.

9. Makeup water to the demineralizer water storage tank (Section 10.4.9). Protection from reverse flow is provided by a backflow preventer.

10. Seal water to the condensate demineralizer - mixed bed tank (Section 10.4.6). Protection from reverse flow is provided by a backflow preventer.

11. Seal water to the Millstone 2 condensate demineralizer - mixed bed tank. Protection from reverse flow is provided by a backflow preventer.

12. Flushing connection for the Millstone 2 condensate demineralizer - mixed bed system. Protection from reverse flow is provided by a backflow preventer.

13. Supply water to the electric steam generator in the warehouse for humidity control. Protection from reverse flow is provided by a backflow preventer.

14. Supply water throughout the entire site for general maintenance and washdown. Protection from reverse flow is provided by sillcocks with integral vacuum breakers.

15. Supply water for sodium hypochlorite injection into service water.

Domestic water is maintained at a constant pressure by a pressure regulating valve for either high demand or low demand periods.

Plant hot water is provided by heating domestic water, using a 48 kW electric water heater with a 2,000 gallon hot water storage tank. Separate electric hot water heaters are provided in the control building to minimize the risk of water flooding in the control room level. The warehouse, and the condensate polishing area are also provided with independent electric hot water heaters.

Vacuum breakers are provided to prevent reverse flow into the domestic water system at all service sink faucets with hose connections, washdown hose connections, and lavatory faucets with hose and tubing connections. Backflow prevention in urinals and water closets is achieved by an air gap.

In the domestic water systems, shock absorbers are used at the ends of branch lines to sanitary fixtures, to minimize the effects of water hammer.

The domestic and sanitary water systems are designed in accordance with the National Plumbing Code and Industry Standards.

9.2.4.3 Safety Evaluation

The failure of the domestic and sanitary water systems will have no effect on the safety of the plant. However, portions of the domestic and sanitary water systems in the control building are seismically supported, to assure that the failure of the piping will not cause a loss of positive pressure in the control building.

As an additional backup for cooling water for cold shutdown, a domestic water connection to the demineralized water storage tank is provided. The connection consists of a spool piece and backflow preventer.

A fire hose adapter, stored in the DWST cubicle, can be connected to refill the DWST from fire water via a fire hydrant or any other water source.

9.2.4.4 Inspection and Testing Requirements

The domestic water system is inspected and tested hydrostatically at 150 percent of their design pressure. The domestic water system is disinfected in accordance with the local codes or American Water Works Association (AWWA) standard C601. The systems are then flushed clean until no chlorine remains in the water coming from the system and left full of water ready for use.

The sewage pump discharge piping is tested to 150 percent of the sewage pump shutoff head.

After installation of the sanitary system piping is completed, and before any fixtures are set, a hydro test is made. During cold weather when water testing is not suitable, air testing may be used with 5 psi minimum pressure.

A final test is made after all fixtures are installed by filling the traps with water and inspecting entire system for tightness.

9.2.4.5 Instrumentation Requirements

The branch line from the extension of the town of Waterford public water supply to the plant domestic water supply has two self-contained pressure control valves connected in parallel. One of these valves is sized to control domestic water pressure during periods of high demand, with the other sized for periods of low demand.

The temperature of the water in the domestic hot water storage tank is sensed by a temperature indicating controller which modulates an electric heater in order to maintain a constant domestic hot water temperature. Whenever the water temperature in the hot water return line decreases to a predetermined setpoint, a temperature switch automatically starts the hot water recirculation pump which runs until the return hot water temperature increases to its normal setting.

9.2.5 ULTIMATE HEAT SINK

The ultimate heat sink for Millstone 3 is Long Island Sound. Sensible heat removed from both safety and non safety-related cooling systems during normal operation, shutdown, and accident conditions is discharged via the service water and circulating water systems.

9.2.5.1 Design Bases

The ultimate heat sink functions and design of the related service water system are based upon the following criteria:

1. General Design Criterion 2, for structures housing the system itself being capable of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods.

2. General Design Criterion 44 for:

   a. The capability to transfer heat loads from safety related structures, systems, and components to the heat sink under both normal operating and accident conditions.

   b. Suitable component redundancy so that safety functions can be performed assuming a single active component failure coincident with loss of off site power.

   c. The capability to isolate components, systems, or piping if required so that safety functions are not compromised.

3. Regulatory Guide 1.27 for the design and functional requirements of the ultimate heat sink.

4. Regulatory Guide 1.29 for the seismic design classification of system components.

5. Regulatory Guide 1.102 for the protection of structures, systems, and components important to safety from the effects of flooding.

6. Regulatory Guide 1.117 for the protection of structures, systems, and components important to safety from the effects of tornado missiles.

The ultimate heat sink is also discussed in Section 2.4.11.6.

9.2.5.2 System Description

The intake structure for Millstone 3 cooling water systems, the circulating and service water pump house (Section 10.4.5) is situated on the shoreline of Niantic Bay. The service water cubicle inside the pump house meets Seismic Category I requirements. It is also designed to withstand the effects of all natural phenomena and missiles (Section 3.8.1). Millstone 1, 2, and 3 each have separate pump houses. The suction bells of the Millstone 3 circulating and service water pumps are located at elevation minus 19.5 feet msl and elevation minus 13.0 feet msl, respectively. The floor of the pump bays is at elevation minus 28.0 feet msl.

The service water cubicle inside the pump house is designed for flood protection to elevation 25.5 feet msl. During a probable maximum hurricane (PMH) a standing wave (clapotis) could form on the front wall of the pump house (Section 2.4.5). The maximum clapotis crest would reach elevation plus 41.2 feet msl. The front wall of the pump house is designed to withstand the external loading from this standing wave and to prevent overtopping.

9.2.5.3 Safety Evaluation

System redundancy is provided to assure availability of service water during accident situations (Section 9.2.1). The service water system consists of two independent flow paths each supplying cooling water to the safety related components; each flow path is provided with two pumps (one operating, one standby).

The Millstone 3 service water and circulating water systems discharge into the circulating water discharge tunnel. The tunnel is a reinforced concrete structure. The circulating water discharge tunnel is designed to Seismic Category I requirements. Therefore, structural failure of the circulating water discharge tunnel is not postulated. The circulating water discharge tunnel connects with the quarry which feeds into Long Island Sound through an open channel located at the south end of the Millstone peninsula. Millstone 1, 2, and 3 all discharge their cooling water into the quarry. In the event that the quarry outlet becomes blocked due to a seismic event or debris clogging, the service water from all three units will flood the quarry discharge area and eventually drain off into Long Island Sound, without restricting the Millstone 3 service water system’s heat removal capability or flooding any safety related structures of Millstone 1, 2, and 3.

Historical low temperatures entering the main condenser via the circulating water system have been recorded below the Service Water system low design basis temperature of 33°F. Regulatory Guide 1.27 for the Ultimate Heat Sink allows operation at temperatures other than the extreme, providing operation at the extreme is rare and occurs for short durations. Evaluation of historical data determined that operation at intake temperatures below 33°F has occurred less than 1% of the plant operating life. An evaluation has been performed of all components and systems interfacing with the Service Water system for operation with temperatures between 28°F and 33°F and has concluded that all equipment will function and perform as required. Operating procedures for the safety injection pump cooling system (See Section 9.2.2.5) require the cooling water pumps to be operated when the ultimate heat sink temperature is below 33°F to prevent freezing of stagnant cooling water in the heat exchanger.

9.2.5.4 Inspection and Testing Requirements

Section 9.2.1 discusses these requirements for the service water system.

9.2.5.5 Instrumentation Requirements

Section 9.2.1 discusses these requirements for the service water system.

9.2.6 CONDENSATE MAKEUP AND DRAWOFF SYSTEM

Condensate storage is provided by the condensate makeup and drawoff system as shown on Figure 9.2–9.

9.2.6.1 Design Basis

The condensate surge tank provides the makeup and drawoff requirements of the main condensate system (Section 10.4.7) and the auxiliary boiler feedwater and condensate system (Section 10.4.10). The surge tank also accepts drawoff from the turbine plant sampling system (Section 9.3.2) and the condensate demineralizer liquid waste system (Section 11.2.2).

The condensate storage tank provides makeup or process water, as required, for the following:

1. Condensate surge tank
2. Auxiliary feedwater system (Section 10.4.9)
3. Reactor plant aerated drains system (Section 9.3.3)
4. Reactor plant component cooling water system (Section 9.2.2)
5. Emergency diesel engine jacket cooling water system (Section 9.5.5)
6. Turbine plant component cooling water system (Section 9.2.7)
7. Chemical feed condensate system (Section 10.4.7)
8. Demineralized water makeup system (Section 9.2.3)
9. Generator stator cooling system (Section 10.2)
10. Condensate polishing demineralizer system (Section 10.4.6)
11. Condensate makeup under turbine skirt

All of the above systems, are normally isolated from the condensate storage tank. Flow is provided on demand by operation of either control or manual valves located in the interfacing system, except for turbine skirt makeup and the water treating system, in which case the valves are located in the condensate makeup and drawoff system.

Drawoff to the condensate storage tank is provided for the condensate demineralizer liquid waste system (Section 11.2.2).

The Millstone 3 condensate storage facilities are not shared with other units on the site. The condensate storage and surge tanks and related piping are classified as nonnuclear safety and designed to Quality Group D standards as defined in Regulatory Guide 1.26 (Section 3.2.2).

The condensate storage and surge tanks and piping are non seismic and are not protected from the effects of tornados, missiles, or floods. No portion of the condensate storage facility piping is classified as high energy piping. The condensate storage facility and piping need not be protected from the effects of moderate and high energy pipe breaks except where flooding would impair safe shutdown of the plant (Section 3.6).

The following systems receiving makeup water from the condensate storage tank are safety related:

1. Auxiliary feedwater system (Section 10.4.9)

2. Reactor plant component cooling water system (Section 9.2.2)

3. Emergency diesel engine jacket cooling water system (Section 9.5.5)

The auxiliary feedwater system normally receives makeup from the safety related demineralized water storage tank which contains sufficient cooling water for the auxiliary feedwater system to fulfill its safe shutdown function (Section 10.4.9). Valves in the condensate makeup lines to the motor driven auxiliary feedwater pump suctions are normally isolated by safety related air operated valves. These valves fail in the closed position. The reactor plant component cooling water surge tank and the emergency generator diesel fresh water expansion tanks have adequate storage capacity, such that safe shutdown of the plant would not be impaired by a failure of the condensate storage tank. Makeup lines to the reactor plant component cooling water system surge tank contain level control valves, which are closed during normal plant operation. Lines to the emergency generator diesel fresh water expansion tanks contain safety related local manual valves, which are closed during normal plant operation.

9.2.6.2 System Description

To maintain normal water levels, water is supplied from the water treating system (Section 9.2.3) to the condensate storage and surge tanks. During startup, water may be supplied to the condensate tanks from the domestic water system. Makeup from the domestic water system is deoxygenated and demineralized. By circulating water through a pump and heater loop, heating is provided for each tank to maintain a minimum water temperature of 40°F. All equipment, piping, and valves in the heater circulation loops are located in the yard and are therefore heat traced to prevent freezing. The 300,000 gallon condensate storage tank and 150,000 gallon condensate surge tank provide makeup and surge inventory of high quality condensate for the main condensate system (Section 10.4.7) and the other plant systems which are listed in

Section 9.2.6.1. The surge tank inventory is normally maintained at a level that will allow for surges from the condensate system in the event of load transients.

On low water level in the condenser hot well, condensate is drained by gravity from the surge tank to the hot well. On high water level in the condenser hot well, the excess condensate is returned to the surge tank by the condensate pumps. Level is maintained in the condensate storage tank by means of the water treating supply pumps. The condensate storage tank overflow is drained to the yard storm sewer system. The condensate surge tank overflows to the turbine building floor drains sump (Section 11.2).

The condensate storage tank is stainless steel construction and is designed, fabricated, and tested in accordance with API-650. The condensate surge tank is aluminum construction and is designed, fabricated, and tested in accordance with ANSI B96.1.

A nitrogen blanket is maintained in each condensate tank to prevent the intrusion of oxygen into the tank inventories. A vacuum breaker and pressure relief valve is provided on each tank to prevent exceeding the tank design pressure.

9.2.6.3 Safety Evaluation

The condensate storage and surge tanks are not safety related. The following design evaluation is provided to demonstrate the system capability to perform its intended function without significant environmental effects.

Under design conditions, the condensate system could contain trace quantities of radioactive isotopes, which are listed for the condenser in Section 10.4.1. Under normal operating conditions, the condensate system contains no radioactivity. Excess condensate returning to the surge tank contaminates only the contents of that tank. The condensate surge tank overflow and drain are piped to the turbine building sump from which they can be pumped to either the yard storm sewer system (normal path) or the turbine building component cooling drain sump, if contaminated. Contaminated surge water can then be pumped to the radioactive liquid waste system for processing.

These precautions are taken although the concentrations of radioactive isotopes are such that any leakage or spillage would have little effect on the environment.

The condensate storage tank is not directly connected with the main condensate system nor the auxiliary boiler steam and condensate system. Therefore, contamination is not expected and the condensate storage overflow and drain are piped to the yard storm drains. The condensate surge and storage tanks are connected by a line containing a normally closed gate valve and a check valve, to prevent backflow from the surge tank into the storage tank.

Safe shutdown of the plant would not be impaired by loss of all condensate in the condensate storage facilities. The safety related systems which receive water from the condensate storage tank have either a safety class primary water supply or have sufficient storage capacity as discussed in Section 9.2.6.1 to perform their safety functions without additional makeup.

Makeup or process water from the condensate storage tank to all systems excluding the surge tank and auxiliary feedwater system is provided by either of two identical component cooling water makeup pumps. During normal operation, only one pump is operating. The second pump is on standby and starts automatically upon malfunction of the first.

9.2.6.4 Inspection and Testing Requirements

The condensate storage and surge tanks are filled with water and examined for leaks after construction. Continuous level checks and periodic visual checks assure proper operability of the condensate storage facility. Samples are taken periodically from the condensate storage and surge tanks to monitor water purity.

9.2.6.5 Instrumentation Requirements

The condensate storage facilities system operating parameters are monitored, indicated, and controlled, locally or remotely, as follows:

1. The component cooling water makeup pumps, are controlled from the main board in the control room by control switches with indicating lights. The makeup valves to the condensate surge and storage tanks are a part of the water treating system.

2. The condensate drawoff control valve, the normal makeup control valve, and the emergency makeup control valve for the condenser hot well can be controlled from the main board manually or locally by AUTO-MANUAL control stations.

3. The condensate storage and surge tank makeup valves are part of the water treatment system and are controlled locally.

Annunciators are provided on the main board to alarm when the following conditions exist:

1. Condensate storage tank temperature Low

2. Condensate surge tank temperature Low

3. Component cooling water makeup pump standby pump running

4. Component cooling water makeup pump discharge pressure Low

5. Condensate storage tank level High or Low

6. Condensate surge tank level High or Low

7. Condensate surge tank level Low-Low

8. Condenser hot well level High or Low

9. Heat tracing panel trouble

10. Any MCC power not available (common)

Indicators are provided on the main board for condensate storage tank level and for condensate surge tank level. There is also a recorder for the condenser hot well water level.

A status window is provided for MCC7B1 load power not available.

The condensate storage tank and surge tank heater circulation pumps are controlled locally and from the turbine plant sampling panel by control switches with indicating lights. The pumps can be controlled from the turbine plant sampling panel when the local control switch is selected to AUTO. The condensate storage tank and surge tank heaters are controlled locally by control switches with indicating lights. The tank pumps and heaters automatically operate to maintain their respective tank temperatures above 40°F.

Level indicating controllers are provided locally for the following valves:

1. Condensate drawoff control valve

2. Normal makeup control valve

3. Emergency makeup control valve

The following parameters are monitored by the plant computer:

1. Emergency makeup control valve not fully closed

2. Water treating total flow to condensate storage tank

3. Water treating total flow to condensate surge tank

4. Auxiliary boiler total flow to condensate surge tank

5. Condensate surge tank total flow to auxiliary boiler

6. Liquid waste system total flow to condensate surge tank

7. Component cooling water makeup discharge total flow

8. Liquid waste system total flow to condensate storage tank

9.2.7 TURBINE PLANT COMPONENT COOLING WATER SYSTEM

The turbine plant component cooling water system (Figure 9.2–10) removes heat from various nonsafety related turbine plant components.

9.2.7.1 Design Bases

The turbine plant component cooling water system provides a closed loop cooling water supply to the following turbine plant components:

1. Turbine lubrication oil coolers (Section 10.2)
2. Electrohydraulic control fluid coolers (Section 10.2)
3. Service and instrument air compressors and after-coolers (Section 9.3.1.1)
4. Generator stator cooling water coolers (Section 10.2)
5. Fourth point heater drain pump coolers (Section 10.4.7)
6. Auxiliary boiler blowdown vent condenser (Section 10.4.10)
7. Isolated phase bus duct coolers (Turbine Building side) (Section 10.2)
8. Exciter air cooler (Section 10.2)
9. Generator hydrogen coolers (Section 10.2)
10. Feedwater pump coolers (Section 10.4.7)
11. Vacuum priming seal water coolers (Section 10.4.5)
12. Turbine plant sample system (Section 9.3.2.2)
13. Condensate pump motor thrust bearing oil coolers
14. Moisture separator drain pump seal coolers and motor thrust bearing oil coolers (Section 10.4.7)
15. Condenser air removal pumps seal water coolers (Section 10.4.2)
16. Deaerator vacuum pumps seal water coolers (Section 9.2.3)
17. Auxiliary boiler condensate and feedwater sample coolers (Section 9.3.2.2)
18. Warehouse area self-contained air conditioning unit (Section 9.4)
19. Hot Water Heating Sample Cooler (Section 9.3.2.2)

Each of the turbine plant component cooling water pumps and heat exchangers is designed to provide 50 percent of the maximum heat load cooling capacity for normal unit operation which would occur with a service water temperature of 80°F. At other times, each heat exchanger and pump is capable of supplying more than 50 percent of the cooling capacity.

9.2.7.2 System Description

Turbine plant component cooling water is pumped through shell and tube turbine plant component cooling heat exchangers, where it is cooled by service water (Section 9.2.1). The cooled water then passes to the components listed in Section 9.2.7.1.

The turbine plant component cooling water system is designed as a closed system. Variations in volume due to temperature changes are accommodated by the turbine plant component cooling surge tank located at the pump suctions. The turbine plant component cooling surge tank is the high point of the system and provides the net positive suction head for the turbine plant component cooling pumps.

Pumps, tanks, heat exchangers, and the remainder of the equipment cooled by the turbine plant component cooling water system listed in Section 9.2.7.1 are located in the turbine building, auxiliary boiler enclosure, and warehouse facility.

Cooling water return lines from each component contain valves for controlling flow. The valves are manually operated globe valves, positioned before unit startup, or automatic air-operated type, positioned by pressure or temperature control signals originating in the cooled system.

Relief valves are provided on all equipment which might be over pressurized by a combination of closed cooling water inlet and outlet valves and heat input from the isolated equipment.

Turbine plant component cooling surge tank level is automatically controlled. The tank capacity is sufficient to accommodate minor system surges and thermal expansion. The turbine plant component cooling surge tank is provided with a high/low level alarm to alert the operator to a possible malfunction of the makeup valve or leakage system.

Makeup for the surge tank is supplied from the condensate makeup and drawoff system (Section 9.2.6). An air-operated valve in the supply line is automatically controlled from a surge tank level switch.

System water chemistry for corrosion inhibition is maintained by chemical additions. A turbine plant component cooling chemical addition tank is connected to the turbine plant component cooling pumps discharge piping. To add chemicals to the system, the tank is isolated, drained, and filled with the desired chemicals. The tank isolation valves are then opened, and the discharge pressure of the operating pump forces water through the tank, injecting the mixture into the turbine plant component cooling pump suction header.

9.2.7.3 Safety Evaluation

The turbine plant component cooling water system is not safety related and is designated to nonnuclear safety class. Failure of any portion or component of this system will not damage any safety related component or system. The following design evaluation is provided to demonstrate the system capability to perform its intended function.

The turbine plant component cooling water system uses equipment and components of conventional and proven design. All components are specified to provide maximum reliability.

The low pressure, high temperature, and surge tank high/low level alarms alert the operator to malfunctions in the system. During normal operation, two turbine plant component cooling pumps and turbine plant component cooling heat exchangers accommodate the heat removal load. The third pump and heat exchanger are spares so that, in the event of a pump or heat exchanger failure, a replacement component is available.

9.2.7.4 Inspections and Testing Requirements

During the life of the unit, all portions of the turbine plant component cooling water system are either in continuous or intermittent operation, and performance tests are not required. The third pump is rotated in service on a scheduled basis for equal wear. All components are accessible for visual inspections which are conducted periodically and following installation of spare parts or piping modifications to confirm normal operation of the system. Routine pre-startup inspections are performed, in addition to periodic observation and monitoring of the system parameters during operation.

9.2.7.5 Instrumentation Requirements

The turbine plant component cooling system operating parameters are monitored, indicated, and controlled locally or remotely.

Instrumentation and controls are provided for the turbine plant component cooling water system to monitor system parameters and alert the operator to any component malfunction. Process variables of components, required on a continuous basis for the startup, operation, or shutdown of the subsystem, are controlled from, indicated, and alarmed in the control room. Those variables which require minimal operator attention have local indicators.

Turbine plant component pump motor control switches, indicating lights and motor ammeters, are provided on the main control board. Ammeters and indicator lights are also provided at the switchgear. Two pumps are normally running and if a pump breaker is automatically tripped, it is alarmed on the main control board. Each pump’s breaker position is monitored by the main computer system. The turbine plant component cooling water heat exchanger outlet pressure is monitored by a pressure indicator on the main control board. Low outlet pressure is alarmed on the main control board; and if pressure continues to drop to a predetermined value, the standby pump is automatically started. The outlet of each heat exchanger is monitored for high temperature by the computer. Return flow temperature is indicated on the main control board and return flow high temperature is monitored by the computer. Turbine plant component cooling supply flow is indicated on the main control board and high or low supply flow is alarmed on the main control board.

The turbine plant component cooling surge tank makeup valve can be controlled manually from the main control board or automatic control can be selected. High and low level alarms are provided in the control room to warn the operator of trouble in the system.

9.2.8 PRIMARY GRADE WATER SYSTEM

The primary grade water system supplies makeup and flushing water throughout the reactor plant. The primary grade water system consists of two primary grade water storage tanks, two primary grade water supply pumps, tank heating loops with electric heater and circulating pump, deaerator with deaerator vacuum skid, deaerator supply and effluent pumps, piping, valves, instrumentation and controls (Figure 9.2–11). Table 9.2–16 gives details of the components in the system and Table 9.2–17 gives primary grade water chemistry specifications.

9.2.8.1 Design Bases

The primary grade water system is nonnuclear safety class, except for the piping between the containment isolation valves which is Safety Class 2.

The primary grade water storage tanks provide sufficient storage capacity to supply the required makeup water to the reactor coolant system (Chapter 5) via the chemical and volume control system (Section 9.3.4) and to store recovered water from the boron recovery system (Section 9.3.5) and the radioactive liquid waste system (Section 11.2.2). The capacity of the primary grade water storage tanks is determined using the following criteria:

1. To provide adequate primary grade water for one cold startup through about 95 percent of a core fuel cycle without any makeup water availability from the demineralized water makeup system (Section 9.2.3)

2. To provide 150 gpm of primary grade water spray for a period of 1 hour to the pressurizer relief tank (Section 5.4.11)

3. To provide contingency of 10 percent over the capacity determined above

Primary grade water supply pump capacity is based on the following criteria:

1. To supply makeup water to boric acid blender at 75 gpm at 60 psig, or to supply cooling water to pressurizer relief tank at the rate of 150 gpm at 65 psig

2. To supply various systems at approximately 50 gpm for miscellaneous services such as makeup, mixing, flushing, etc.

Primary grade water storage tanks are provided with nitrogen blanketing to eliminate air ingress into the deoxygenated water in the tanks, and with a nitrogen sparger to deoxygenate the water to below 100 ppb.

In addition, a 200 gpm deaerator is provided as an alternate means to reduce the oxygen content of primary grade water to below 100 ppb. A 200 gpm supply pump supplies primary grade water to the deaerator and a 200 gpm deaerator effluent pump returns deaerated primary grade water to either the primary grade water storage tanks or the primary grade water supply pumps.

During normal operation, primary grade water has a boron concentration of less than 5 ppm and may have a slight amount of radioactivity ($5x10^{-4}$ μCi/cc maximum) due to possible activity carryover from the boron recovery system (Section 9.3.5).

9.2.8.2 System Description

The primary grade water system is a storage and distribution system for primary grade water. This water is used exclusively by reactor plant systems; it is not supplied to any turbine plant system.

The initial fill and makeup for the primary grade water system is supplied from the demineralized water makeup system (Section 9.2.3) and, therefore, consists of demineralized and deaerated water. Table 9.2–17 lists the water chemistry specifications.

Primary grade water is capable of being recovered from the reactor coolant letdown which has been stripped of dissolved gases in the radioactive gaseous waste system (Section 11.3) and essentially freed of boric acid, cesium, and other radioactive material in the boron recovery system (Section 9.3.5). When feasible, primary grade water is capable of being recovered from reactor plant aerated drains by the radioactive liquid waste system.

The functions of the primary grade water system are:

1. To supply makeup water to the reactor coolant system via the chemical and volume control system (Section 9.3.4).

2. To provide the initial supply of quenching water in the pressurizer relief tank and to cool the contents of the pressurizer relief tank after pressurizer relief (Section 5.4.11).

3. To flush spent resin from the ion exchangers, demineralizers, and associated piping in the radioactive solid waste system (Section 11.4).

4. To supply water to the spent fuel pool (Section 9.1.3) to compensate for evaporation losses.

5. To supply seal injection to the waste evaporator feed pumps and waste evaporator reboiler pump (Section 11.2), and to the boron evaporator reboiler pump and boron distillate pump (Section 9.3.5). Waste evaporator reboiler pump is no longer in service.

6. To supply mixing and flushing water for the waste solidification process in the radioactive solid waste system (Section 11.4).

7. To provide mixing water for the boric acid batching tank.

8. To provide primary grade water to the neutron shield tank surge tank (Section 9.2.2.3).

9. To supply hose connections in the waste disposal building, auxiliary building, and reactor vessel head storage stand area.

To accomplish these functions, the system requires approximately 200,000 gallons of primary grade water. Two half size tanks are provided to avoid possible inadvertent contamination of the entire stored water capacity when liquid is being received from the boron recovery system or radioactive liquid waste system, and to provide operational flexibility. This permits feeding from one tank and receiving in the second tank simultaneously. In addition, boron test tanks in the boron recovery system prevent inadvertent contamination of the primary grade water storage tanks. Sampling of the water in these tanks occurs before the contents are transferred to primary grade water tanks. If a decision is made to further reduce the boron concentration in the liquid after the liquid has been transferred to a primary grade water storage tank, the tank contents can then be circulated through the boron demineralizer and boron demineralizer filter of the boron recovery system.

Since the primary grade water storage tanks are located outdoors, an external forced circulation heating loop protects the tanks from freezing. Each heating loop has an electric heater and a circulation pump. No redundancy is provided since the equipment is expected to be in use for limited periods during the year and limited heating can be provided by operating the primary grade water supply pumps on recirculation and by circulating deoxygenated water through the primary grade water deaerator. Each tank is provided with a low pressure nitrogen blanket over the water surface to preclude air ingress into the deoxygenated water in the tank.

Each tank is also provided with two sets of combination pressure relief (to exhale during tank fill) and vacuum breaker (to inhale air upon loss of nitrogen) valves. The nitrogen blanket is supplied with a low pressure nitrogen from a control station, fed from a liquid nitrogen storage tank 3GSN-TK2 (see Section 9.5.9.2).

Each of the two primary grade water supply pumps is designed to provide 200 gpm at 81.5 psig. The pumps are provided with recirculation to the primary grade water storage tanks for pump protection in the event of reduced system demand.

Makeup to the reactor coolant system and pressurizer relief tank spray is not expected to occur simultaneously, therefore, only one of the two primary grade water supply pumps is required to operate. Pressurizer relief tank spray that cools down the tank and its contents is carried out manually after an event which results in opening of pressurizer relief valves.

A nitrogen sparger, installed at the bottom of each tank, is operated to reduce the dissolved oxygen content of primary grade water if the water, when sampled from the tank, exceeds the allowable 0.1 ppm. As an alternate, the vacuum deaerator can be used. The deaerator can also be used “in-line” with the pump which is supplying normal primary grade water. The deaerator is a cold water type, having a large vertical column with ceramic packings. Inlet water is sprayed at the evacuated top of the deaerator where most of dissolved gases separate out. Further deaeration is provided by the cascading and scrubbing action in the packings.

The deaerator supply pump is designed to provide 200 gpm at 61.7 psig to the primary grade water deaerator. The deaerator effluent pump returns the primary grade water to the suction of the primary grade water supply pump and/or the primary grade water storage tanks. The vacuum in the deaerator is maintained by a steam jet air ejector system. Auxiliary steam flow through the steam ejector draws the vacuum. Condensate from this system (less than 0.4 gpm) is routed to the reactor plant aerated drains system for further processing in the low level radioactive waste system (Section 9.3.3).

9.2.8.3 Safety Evaluation

The primary grade water system provides a reliable source of water for reactor coolant makeup, cooling water for the pressurizer relief tank, and miscellaneous services such as mixing and flushing, etc. Two primary grade water storage tanks provide redundancy and flexibility. The use of two half-size primary grade water storage tanks ensures that the entire supply of primary grade water does not become contaminated. In the event of high boron concentration in one primary grade water storage tank, all the water in the tank is reprocessed by the boron recovery system, while system makeup can be supplied from the other tank. If dissolved oxygen level in any of the primary grade water tanks exceeds the specified level, the tank is sparged with nitrogen, or the makeup water is processed by the deaerator. Each of the two full capacity primary grade water supply pumps can deliver sufficient primary grade water to all users as detailed above.

Primary grade water system lines penetrating the containment structure are isolated on a containment isolation phase A (CIA) signal (Section 7.3). These Safety Class 2 lines and associated valves are designed for SSE, are tornado missile protected, and not subject to the effects of pipe whip (Section 3.6).

The system does not use or generate any chemicals and, therefore, poses no spill hazard. A postulated failure of nonnuclear safety class piping results in low pressure in primary grade water header. An alarm and low flow indication on the main control board will alert the operator to shut down the operating primary grade water supply pump and take action to isolate the leak. Neither a pipebreak nor an oversupply of water to the primary grade water storage tanks will result in flooding of any building containing safety class components or affect any safety class equipment. All safety class equipment is located at elevations higher than a water level which would result if flooding continued for 30 minutes until the leak was isolated by the operator. Loss of capability to provide water to the reactor coolant system does not result in loss of the ability of the plant to achieve and maintain safe shutdown. Since primary grade water activity is limited to less than $5x10^{-4}$ μCi/cc, any inadvertent discharge to the environment due to a pipe or tank failure results in no more than 0.4 Ci (excluding tritium) being released to the environment.

9.2.8.4 Inspection and Testing Requirements

A program of testing and inspections ensures that the design basis capability of the primary grade water system is maintained throughout its design life. Primary grade water storage tanks are sampled for conformance with the chemistry criteria given in Table 9.2–17. Standby pumps are used on a periodic basis to ensure their availability. Continuously operating equipment is visually examined at appropriate opportunities to ensure their operability. Routine maintenance checks are performed to ensure that the standby equipment performs upon failure of the operating component.

9.2.8.5 Instrumentation Requirements

The primary grade water system operating parameters are monitored, indicated, and controlled, locally or remotely, as follows:

A forced circulation electric heating loop for each primary grade water storage tank maintains a minimum temperature of 40°F. The circulating pumps can be controlled manually or automatically from a local control panel and can be controlled manually from the reactor plant sample station. Temperature elements are installed in the storage tanks and in the circulating pump suctions. The temperature elements control the electric heater, automatically start the circulating pump, and activate low temperature annunciators on the main control board. The electric heater is protected from overheating and is interlocked with the circulating pump. The circulating pump must be running to energize the electric heater.

A level switch automatically stops the circulating pump if primary grade water storage tank level is low. A pressure indicator is installed in the discharge of each circulating pump, and a temperature indicator is installed at the outlet of each electric heater.

A level indicator transmitter is installed on each storage tank, and the level is indicated on the main control board. Low and high levels are annunciated on the main control board and the level is monitored by the computer.

Both primary grade water supply pumps can be operated manually from the main control board. One pump runs continuously and the second pump can be started manually by the operator if a low discharge flow is indicated on the main control board or if the first pump is stopped. The primary grade water supply pumps are automatically stopped on low suction pressure resulting from a low level in the primary grade water storage tank. Primary grade water supply discharge low pressure is annunciated on the main control board.

The deaerator portion of the system is monitored as follows:

The deaerator supply pump and effluent pump are operated manually at the local control station. The supply pump is automatically stopped on low suction pressure or high level in the vacuum deaerator. The effluent pump is stopped automatically by low level in the vacuum deaerator.

Condensate level is maintained in the high vacuum exhauster intercondenser by using a high and low level switch respectively to start and stop the condensate pump.

Flow to the vacuum deaerator is controlled by a flow controller and flow valve at the deaerator inlet. Level in the vacuum deaerator is controlled by a level valve and controller at the deaerator outlet.

Local pressure indicators, temperature indicators, and flow indicators monitor system parameters.

9.2.9 REFERENCES FOR SECTION 9.2

9.2-1 NUREG-1838, "Safety Evaluation Report Related to the License Renewal of the Millstone Power Station Units 2 and 3, Dockets Nos. 50-336 and 50-423, Dominion Nuclear Connecticut, Inc." October 2005.

TABLE 9.2–1 SERVICE WATER SYSTEM FLOW REQUIREMENTS

					DBA Coincident with Loss of Power				Loss of Power with Train Failure			
	Normal Operating Condition		Normal Unit Cooldown Condition		Minimum ESF		Normal ESF		Hot Standby and Cooldown to RHS Entry Conditions		Cooldown to Cold Shutdown Conditions	
Component	No. of Comp. Oper.	Req. (gpm)	No. of Comp. Oper.	Req. (gpm)	No. of Comp. Oper.	Req. (gpm)	No. of Comp. Oper.	Req. (gpm)	No. of Comp. Oper.	Req. (gpm)	No. of Comp. Oper.	Req. (gpm)
Reactor plant component cooling heat exchangers (Total 3) [1]	2	14,776	2	18,000 [2]	0	0	0	0	1	< 4,400 [3]	1	7,388 [2]
Turbine plant component cooling heat exchangers (Total 3)	2	9,950	2	9,950	0	0	0	0	0	0	0	0
Containment recirculation coolers (Total 4)	0	0	0	0	2	10,800	4	21,600	0	0	0	0
Control building air-conditioning heat exchangers (Total 2)	1	303	1	303	1	303	1	303	1	303	1	303
Containment recirculation pumps ventilation units (Total 2)	0	0	0	0	1	31	2	62	0	0	0	0
Residual heat removal pumps ventilation units (Total 2)	0	0	2	49.94	1	24.97	2	49.94	0	0	1	24.97
Charging pumps coolers (Total 2) [4]	2	62.4	2	62.4	1	31.2	2	62.4	1	31.2	1	31.2
Safety injection pumps coolers (Total 2) [4]	2	24	2	24	1	12	2	24	1	12	1	12
Emergency generator diesel engine coolers (Total 2)	0	0	0	0	1	1,800 [5]	2	3,600 [5]	1	1,800 [5]	1	1,800 [5]

TABLE 9.2–1 SERVICE WATER SYSTEM FLOW REQUIREMENTS (CONTINUED)

					DBA Coincident with Loss of Power				Loss of Power with Train Failure			
	Normal Operating Condition		Normal Unit Cooldown Condition		Minimum ESF		Normal ESF		Hot Standby and Cooldown to RHS Entry Conditions		Cooldown to Cold Shutdown Conditions	
Component	No. of Comp. Oper.	Req. (gpm)	No. of Comp. Oper.	Req. (gpm)	No. of Comp. Oper.	Req. (gpm)	No. of Comp. Oper.	Req. (gpm)	No. of Comp. Oper.	Req. (gpm)	No. of Comp. Oper.	Req. (gpm)
Service water strainer backwash (Total 4) [6]	2	2,000	2	2,000	1	1,000	2	2,000	1	1,000	1	1,000
Circulating water pumps lubricating water (Total 6)	6	30 [7]	6	30 [7]	0	0	0	0	0	0	0	0
MCC and rod control area booster pumps (Total 2)	0	Note [8]	0	Note [8]	1	100/110	2	100/110	1	100/110	1	100/110
Post-accident liquid sample cooler (Total 1)	0	0	0	0	1	5.1	1	5.1	0	0	0	0

NOTES:

1. 4 hours after a LOCA and initiation of a CDA signal it is necessary for the operator to take action to supply service water to the reactor plant component cooling water heat exchangers.
2. Required flow reflects 10 percent tube plugging. Required flow may be reduced if <10 percent tubes plugged.
3. 4,400 gpm is bounding when used individually for each train.
4. Service water flow is maintained continuously through the charging pump coolers and safety injection pump coolers. Safety Injection pump coolers are required for some fire shutdown events with loss of power and thus are included.
5. Required flow reflects 5 percent tube plugging. Required flow may be reduced if < 5 percent tube plugged. Note: Tube plugging limit may be reduced by down tube coating.
6. Flow is not continuous.
7. 30 gpm @ maximum allowable pressure drop across strainers.
8. Flow is continuous through the MCC and rod control area cooling coils. The pumps start during normal operation on high area temperatures only.

LEGEND:

No. of Comp. Oper. = Number of Components Operating
Req. = Requirements

TABLE 9.2–2 SERVICE WATER SYSTEM HEAT TRANSFER REQUIREMENTS

					DBA Coincident with Loss of Power				Loss of Power with Train Failure			
	Normal Operating Conditions (1)		Normal Unit Cooldown Condition		Minimum ESF		Normal ESF		Hot Standby and Cooldown to RHS Entry Conditions		Cooldown to Cold Shutdown Conditions	
Component	No. of Comp. Oper.	Req. (10^6 Btu/hr)	No. of Comp. Oper.	Req. (10^6 Btu/hr)	No. of Comp. Oper.	Req. (10^6 Btu/hr)	No. of Comp. Oper.	Req. (10^6 Btu/hr)	No. of Comp. Oper.	Req. (10^6 Btu/hr)	No. of Comp. Oper.	Req. (10^6 Btu/hr)
Reactor plant component cooling heat exchangers (Total 3)	2	111	2	197	0	0	0	0	1	26	1	118
Turbine plant component cooling heat exchangers (Total 3)	2	≈ 66.3	2	≈ 66.3	0	0	0	0	0	0	0	0
Containment recirculation coolers (Total 4)	0	0	0	0	2	617 (3)	4	1234 (3)	0	0	0	0
Control building air-conditioning water chillers (Total 2) (4)	1	2.8	1	2.8	1	2.8	1	2.8	1	2.8	1	2.8
Containment recirculation pumps ventilation units (Total 2)	0	0	0	0	1	0.4	2	0.8	0	0	0	0
Residual heat removal pumps ventilation units (Total 2)	0	0	2	0.72	1	0.36	2	0.72	0	0	1	0.36

TABLE 9.2–2 SERVICE WATER SYSTEM HEAT TRANSFER REQUIREMENTS (CONTINUED)

					DBA Coincident with Loss of Power				Loss of Power with Train Failure			
	Normal Operating Conditions [1]		Normal Unit Cooldown Condition		Minimum ESF		Normal ESF		Hot Standby and Cooldown to RHS Entry Conditions		Cooldown to Cold Shutdown Conditions	
Component	No. of Comp. Oper.	Req. (10^6 Btu/hr)	No. of Comp. Oper.	Req. (10^6 Btu/hr)	No. of Comp. Oper.	Req. (10^6 Btu/hr)	No. of Comp. Oper.	Req. (10^6 Btu/hr)	No. of Comp. Oper.	Req. (10^6 Btu/hr)	No. of Comp. Oper.	Req. (10^6 Btu/hr)
Charging pumps coolers (Total 2) [4]	2	0.162	2	0.162	1	0.081	2	0.162	1	0.081	1	0.081
Safety injection pumps coolers (Total 2) [4]	2	0	2	0	1	0.028	2	0.056	1	0	1	0
Emergency generator diesel engine coolers (Total 2)	0	0	0	0	1	13	2	26	1	13	1	13
MCC and rod control area air-conditioning units (Total 2) [4]	0	0	0	0	1	0.502/0.504	2	1.006	1	0.502/0.504	1	0.502/0.504
Post-accident liquid sample cooler (Total 1)	0	0	0	0	1	0.29 [3]	1	0.29 [3]	0	0	0	0

NOTES:

(1) These are maximum operating heat loads.

(2) N/A.

(3) Heat load is not continuous. This is the temporary peak heat load for the containment recirculation coolers and the post-accident liquid sample cooler.

(4) Service water flow will be maintained continuously through the charging pump coolers, safety injection pump coolers, control building air-conditioning water chillers, and the MCC and rod control area air conditioning units.

LEGEND:

No. of Comp. Oper. = Number of Components Operating

Req. = Requirements

TABLE 9.2–3 AUTOMATIC OPERATION OF SERVICE WATER SYSTEM VALVES

Signal	Service Water Valve	Action Upon [1] Initiation of Signal
1. Loss of Power	Emergency generator diesel engine cooler outlet (AOV) [2]	Valves open
	Reactor plant component cooling heat exchangers inlet supply (MOV) [3]	Valves remain open
	Turbine plant component cooling heat exchangers inlet supply (MOV)	Valves close
	Containment recirculation cooler inlet supply (MOV)	Valves remain closed
	Circulating water pumps lubricating water inlet supply (MOV)	Valves close
2. Containment Depressurization	Emergency generator diesel engine cooler outlet (AOV)	Valves open
	Reactor plant component cooling heat exchangers inlet supply (MOV)	Valves close
	Turbine plant component cooling heat exchangers inlet supply (MOV)	Valves close
	Containment recirculation cooler inlet supply (MOV)	Valves open
	Circulating water pumps lubricating water inlet supply (MOV)	Valves close
3. Safety Injection	Emergency generator diesel engine cooler outlet (AOV)	Valves open
	Reactor plant component cooling heat exchangers inlet supply (MOV)	Valves remain open
	Turbine plant component cooling heat exchangers inlet supply (MOV)	Valves remain open
	Containment recirculation cooler inlet supply (MOV)	Valves remain closed
	Circulating water pumps lubricating water inlet supply (MOV)	Valves remain open
4. Service Water Header Pressure Low	Turbine plant component cooling heat exchangers inlet supply (MOV)	Valves close

NOTES:
1. Required position of valve after initiation of an ESF signal.
2. AOV = air-operated valve
3. MOV = motor-operated valve

TABLE 9.2–4 CONSEQUENCE OF COMPONENT FAILURE

Component	Failure Mode	Comments and Consequences
Service water pump	Pump casing ruptures	The four service water pumps are designed as Seismic and QA Category I. They are missile and tornado protected. Rupture by missiles is not considered credible. Redundant pump will perform safety function.
Service water pump	Original pump fails to operate	Redundant pump will perform safety function.
Service water strainer	Strainer motor fails or strainer elements clog	Redundant strainer-pump arrangement on each discharge line will perform safety function.
System valves	Improper position	Prevented by prestartup and operational checks. When the system is in service, such a condition would be observed by operating personnel monitoring the system parameters.
Control building air-conditioning booster pumps	Pump casing ruptures	There are two full-size booster pumps, one on each redundant service water header. These pumps are designed to Seismic Category I requirements. They are missile protected and may be inspected at any time. Rupture by missiles is not considered credible. Any pump can be isolated by suction and discharge isolation valves. Full capacity will be retained by using the standby pump.
Control building air-conditioning booster pump	Pump fails to operate	Redundant pump will perform safety function.
Control building air-conditioning water chiller condensers	Tube or shell ruptures in one condenser	There are two full-size water chiller condensers one on each redundant service water header. Each water chiller can be isolated in case of rupture. Because of the low operating pressure and temperatures, Seismic Category I design, and missile protection arrangements, such ruptures will be considered noncredible.
MCC and rod control area pump booster	Pump casing ruptures	There are two full-size booster pumps, one on each redundant service water header.

TABLE 9.2–4 CONSEQUENCE OF COMPONENT FAILURE (CONTINUED)

Component	Failure Mode	Comments and Consequences
		These pumps are designed to Seismic Category I requirements. They are missile protected and may be inspected at any time. Rupture by missiles is not considered credible. Any pump can be isolated by suction and discharge isolation valves. Full capacity will be retained by using the standby pump.
MCC and rod control area air-conditioning units	Ventilation unit ruptures	There are two full-size ventilation units, one on each redundant service water header. Each ventilation unit can be isolated in case of rupture. Because of the low operating pressure and temperatures, Seismic Category I design, and missile protection arrangements, such ruptures will be considered noncredible.
Emergency generator diesel engine coolers	Tube or shell ruptures in one cooler	There are two full-size diesel engine coolers, one on each redundant service water header. Each diesel engine cooler can be isolated in case of rupture. Because of the low operating pressure and temperature, Seismic Category I Design, and missile protection arrangements, such ruptures will be considered noncredible.
Emergency generator diesel air-operated isolation valves	Loss of air in accident	Valves fail in open position on loss of air allowing services water flow.
Containment recirculation coolers	Tube or shell ruptures in one cooler	Four 50 percent capacity containment recirculation coolers are provided. Each pair of containment recirculation coolers is supplied cooling water from a separate redundant service water header (Section 6.2.2).
Reactor plant component cooling heat exchangers	Tube or shell ruptures in one heat exchanger	Each of the three heat exchangers can be isolated in case of rupture. Each of the remaining heat exchangers is capable of performing 50 percent capacity (Section 9.2.2) subsystem.
Safety injection pump coolers	Tube or shell ruptures in one cooler	Each of the two coolers can be isolated in case of rupture. The remaining cooler is capable of performing subsystem capacity (Section 9.2.2.5).
Charging pumps coolers	Tube or shell ruptures in one cooler	Each of the two coolers can be isolated in case of rupture. The remaining cooler will be capable of performing subsystem capacity (Section 9.2.2.4).

TABLE 9.2–4 CONSEQUENCE OF COMPONENT FAILURE (CONTINUED)

Component	Failure Mode	Comments and Consequences
Residual heat removal pumps ventilation unit condenser	One ventilation unit condenser ruptures	There are two full-size ventilation units, each with its own condenser. Each condenser can be isolated in case of rupture. Because of the subsystem's low operating pressures and temperatures, Seismic Category I design, and missile protection arrangements, such ruptures will be considered noncredible.
Motor-operated valves	Valve fails to operate	Redundant motor operated valves will perform safety function.
Service Water lines to the hypochlorite system, the post-accident sampling system cooler, circulating water pumps for lube water, and the turbine building component cooling water system	Pipe rupture in nonseismic non-safety related piping	Rupture of Seismic Category II pipe, if not immediately identified, will not adversely affect overall performance of service water system.
Electronically powered components, such as water pumps, and motor-operated valves	Failure of one AC emergency power supply	Redundant electrically operated components will be supplied from independent emergency electric AC buses. The failure of one emergency AC bus will not impair the system safety functions.
Containment recirculation pump ventilation unit condenser	One ventilation unit condenser ruptures	There are two full-size ventilation units, each with its own condenser. Each condenser can be isolated in case of rupture. Because of the subsystem's low operating pressures and temperatures, Seismic Category I design, and missile protection arrangements, such ruptures will be considered noncredible.
Turbine plant component cooling	Tube or shell ruptures in one heat exchanger	Three 50 percent heat exchangers are provided. Each heat exchanger can be isolated in case of a rupture. Motor-operated valves provide barrier isolation for the safety-related portion of the service water system.
Post-accident liquid sample cooler	Tube or shell ruptures	One cooler is provided and may be lined up to either service water train. Manual isolation valves, which are normally closed, provide the barrier isolation for the safety-related portion of the service water system.

TABLE 9.2–5 REACTOR PLANT COMPONENT COOLING SYSTEM MAJOR COMPONENT DESIGN DATA

1.	Component Cooling Surge Tank		
	Number (dual)		1
	Design Pressure (psig)		15
	Design Temperature (°F)		150
	Design Capacity (gal) (total)		14,577
2.	Component Cooling Heat Exchanger		
	Number		3
	Heat transfer rate at design condition (Btu/hr/unit)		76,000,000[1,3] / 75,084,625[2]
		Tube Side	Shell Side
	Design Pressure (psig)	100[1] / 100[2]	185[1] / 185[2]
	Design Temperature (°F)	125[1] / 200[2]	200[1] / 200[2]
	Design Flow (lb/hr)	4,000,000[1] / 5,142,000[2]	4,050,000[1] / 4,000,000[2]
	Fluid	Service Water	Reactor Plant Component Cooling Water
3.	Component Cooling Pump		
	Number		3
	Design Pressure (psig)		250
	Design Temperature (°F)		160
	Design Capacity (gpm per pump)		8,100

NOTES:

Note 1 - 3CCP*E1C per 2214.413-446 (M446)

Note 2 - 3CCP*E1A & 3CCP*E1B per M3-SPEC MP PS-ME-1214 and Holtec Data Sheets

Note 3 - M446 - Normal Plant Operation heat transfer of 76,000,000 based on original manufacturer data sheets

TABLE 9.2–6 CONSEQUENCES OF COMPONENT FAILURES REACTOR PLANT COMPONENT COOLING WATER SYSTEM

Components *	Malfunction	Comment and Consequences
Reactor plant component cooling pumps	Pump casing ruptures	These pumps are designed to Seismic Category I requirements. They are missile protected and may be inspected at any time. Rupture by missiles is not considered credible. Any pump can be isolated by suction and discharge isolation valves. Full system capability is retained by using the standby pump.
Reactor plant component cooling pump	Original pump fails to start	Standby pump is used to achieve full system capability.
Reactor plant component cooling heat exchangers	Tube or shell ruptures	Each heat exchanger can be isolated in case of rupture. Each of the remaining heat exchangers is capable of performing 50 percent system capacity. Because of the system's low operating pressure and temperature, Seismic Category I design, and missile protection arrangements, such rupture is considered unlikely.
System valves	Improper position	Prevented by prestart-up and operations checks. When the system is in service, such a condition would be observed by operating personnel monitoring system parameters.
Cooling water to residual heat exchangers	Pipe rupture in nonseismic piping or seismic piping	The piping not designed to Seismic Category I is isolated, and the seismic portion is split in half. If the rupture occurs in the seismic piping, one-half of the Seismic Category I portion becomes inoperable. The remaining redundant seismic section remains operable to safely bring the reactor coolant system to cold shutdown conditions.
Reactor plant component cooling surge tank	Pipe rupture in surge tank line connecting to pumps	The surge tank is divided; thus, providing a separate source of water for each pump suction from two separate surge lines. The affected pipe line causes loss of one pump, but the suction pressure is maintained on the other pump through the redundant surge line.

TABLE 9.2–6 CONSEQUENCES OF COMPONENT FAILURES REACTOR PLANT COMPONENT COOLING WATER SYSTEM (CONTINUED)

Components *	Malfunction	Comment and Consequences
Electrically powered components, such as reactor plant component cooling pumps, controls, power operated valves	Failure of one power supply bus	Electrically powered components are segregated and each separate group powered from a different emergency bus: one reactor plant component cooling pump, its controls, and valves on one bus; the other pump is on a separate bus; the failure of one bus affects only part of this redundant system, and system function is unimpaired.

NOTE:

* The single failure of any component listed in this table does not preclude safe shutdown of the reactor.

TABLE 9.2–7 CHILLED WATER SYSTEM HEAT LOADS AND FLOW RATES

Component	Flow (gpm)	Heat Load (Btu/hr)
Refueling water coolers (2)	400 (1)	289,200
		(6,252,000) (2) (3)
Potentially contaminated air air-conditioning unit	120	601,400
Clean air air-conditioning unit	110	536,000
Motor control center and rod control area air-conditioning units (2)	190	1,020,000
Reactor coolant pump motors	880	5,970,000
CRDM shroud coolers (2)	880	3,700,000
Containment air recirculation coolers (3)	996 (4)	6,870,000
Neutron shield tank coolers (2)	80	210,000
Process vent cooler	30	147,800
Total	3,686	19,344,400

NOTES:
(1) Cooldown after refueling.
(2) Only one unit supplied at a time.
(3) This heat load is excluded from the total heat load above.
(4) Flow is to all three coolers although only two fans are running at any one time.

TABLE 9.2–8 CHILLED WATER SYSTEM MAJOR COMPONENT DESIGN DATA

Chilled Water Circulating Pumps	
Number	3
Design Pressure (psig)	150
Design temperature (°F)	300
Design capacity (gpm)	2,100
Chilled Water Surge Tank	
Number	1
Design Pressure (psig)	20
Design temperature (°F)	200
Design capacity (gpm)	860
Mechanical Refrigeration Units (chillers)	
Number	3
Capacity at specified conditions (tons)	938 each
Evaporator	
Chilled water temperature, inlet/outlet (°F)	55/45
Chilled water flow (gpm)	2,250
Condenser	
Water temperature, inlet/outlet (°F)	95/105.5
Water flow (gpm)	2,700
Refrigerant charge	
Type	R-12
Weight (lb)	3,400

TABLE 9.2–9 NEUTRON SHIELD TANK COOLING SYSTEM COMPONENT DATA SUMMARY

Neutron Shield Tank	
Number	1
Volume (gal)	32,000
Design pressure (psig)	22
Design temperature (°F)	
Maximum	150
Minimum	65
Material	Carbon steel
Neutron Shield Tank Coolers	
Number	2
Duty (Btu/hr)	226,000
Chilled Water (Shell)	
Capacity (lb/hr)	20,000
Operating pressure (psig)	125
Design pressure (psig)	150
Design temperature (°F)	160
Operating temperature in/out (°F)	50/60.5
Material	Carbon steel
Neutron Shield Tank Water (Tubes)	
Capacity (lb/hr)	7,000
Operating pressure (psig)	10
Design pressure (psig)	15
Design temperature (°F)	160
Operating temperature in/out (°F)	120/90
Material	Copper-nickel
Neutron Shield Tank Surge Tank	
Number	1
Volume (gal)	230
Design pressure (psig)	20
Design temperature (°F)	160
Material	Carbon steel

TABLE 9.2–10 CHARGING PUMPS COOLING SYSTEM COMPONENT DATA SUMMARY

Charging Pumps Cooling Pumps	Data Summary
Number	2
Design pressure (psig)	225
Design temperature (°F)	150
Design flow (gpm)	90
Design head (ft.)	83
Material	Austenitic Stainless Steel
Charging Pumps Cooler	
Number	2
Duty (Btu/hr)	81,000
Cooling Water	
Capacity (gpm)	6.8 - 10.0
Operating pressure (psig)	23
Design pressure (psig)	70
Design temperature (°F)	130
Operating temperature, in/out (°F)	130/106
Service Water	
Capacity (minimum required) (gpm)	31
Operating pressure (psig)	63
Design pressure (psig)	100
Design temperature (°F)	95
Operating temperature, in/out (°F)	80/85
Material	Copper-nickel
Charging Pumps Cooling Surge Tank	
Number	1 (divided wall)
Capacity (gal)	1,000
Design pressure (psig)	3
Design temperature (°F)	150
Material	Carbon steel

TABLE 9.2–11 CONSEQUENCES OF COMPONENT FAILURES, CHARGING PUMPS COOLING SUBSYSTEM

Components	Malfunctions	Comments and Consequences *
Charging pumps cooling pumps	Pump casing ruptures	These pumps will be designed to Seismic Category I requirements. They will be missile protected and may be inspected at any time. Rupture by missiles is not considered credible. Any pump can be isolated by suction and discharge isolation valves. Full system capability will be retained by using the standby pump.
	Original pump fails to start	Redundant pump can be used to achieve full system capability.
Charging pumps coolers	Tube or shell ruptures	Each heat exchanger can be isolated in case of rupture. The remaining heat exchanger will be capable of performing system capacity. Because of the system's low operating pressure and temperature, Seismic Category I design, and location apart from potential missile, such rupture will be considered unlikely.
Subsystem valves	Improper position	Prevented by prestart-up and operational checks. When the system is in service, such condition should be observed by operating personnel monitoring system parameters.
Charging pumps cooling surge tank	Automatic level control fails to operate correctly	The surge tank is a partitioned tank with redundant surge lines. System surge capacity will be provided to the unaffected portion of the tank, and system function will be unaffected. The charging pump cooling system performance will not be affected.
Charging pumps cooling surge tank	Pipe rupture in surge tank line connecting to pumps	The surge tank will be divided, with two sources of water for pump suctions from two separate surge lines. The affected pipeline will be isolated, and suction pressure maintained through the redundant surge line.

TABLE 9.2–11 CONSEQUENCES OF COMPONENT FAILURES, CHARGING PUMPS COOLING SUBSYSTEM (CONTINUED)

Components	Malfunctions	Comments and Consequences *
Electrically powered components, such as charging pumps, charging pumps cooling pumps, controls, power-operated valves	Failure of one power supply bus	Electrically powered components will be separated and each separate group powered from a different emergency bus. One charging pumps cooling pump, its controls and valves will be on one bus; the other pumps will be on a separate bus; failure of one bus will affect only part of this redundant system, and system function will be unimpaired.

NOTE:

* The single failure of any component listed in this table will not preclude safe shutdown of the reactor

TABLE 9.2–12 SAFETY INJECTION PUMPS COOLING SYSTEM COMPONENT DATA SUMMARY

Safety Injection Pumps Cooling Pumps	Data Summary
Number	2
Design pressure (psig)	225
Design temperature (°F)	150
Design flow (gpm)	25
Design head (ft.)	54
Material	Austenitic stainless steel
Safety Injection Pumps Cooling System Cooler	
Number	2
Duty (Btu/hr)	27,900
Cooling Water:	
Capacity (gpm)	10
Operating pressure (psig)	13
Design pressure (psig)	35
Design temperature (°F)	130
Operating temperature, input (°F)	130/124
Material	Copper-nickel
Safety Injection Pumps Cooling System Surge Tank	
Number	1 (divided tank)
Volume (gal)	1,000
Design pressure (psig)	3
Design temperature (°F)	150
Material	Carbon steel

TABLE 9.2–13 CONSEQUENCES OF COMPONENT FAILURES – SAFETY INJECTION PUMPS COOLING SUBSYSTEM

Components	Malfunctions	Comments and Consequences
Safety injection pumps cooling pumps	Pump casing ruptures	These pumps are designed to Seismic Category I requirements. They will be missile protected and may be inspected at any time. Rupture by missiles is not considered credible. Any pump can be isolated by suction and discharge isolation valves. Full system capability is retained by using the standby pump.
	Original pump fails to start	Redundant pump can be used to achieve full system capability.
Safety injection pumps cooling system coolers	Tube or shell ruptures	Each heat exchanger can be isolated in case of rupture. The remaining heat exchanger is capable of performing system capacity. Because of the system's low operating pressure and temperature, Seismic Category I design, and missile protection arrangements, such rupture is considered unlikely.
Subsystem valves	Improper position	Prevented by prestart-up and operational checks. When the system is in service, such condition would be observed by operating personnel monitoring system parameters.
Safety injection pumps cooling system surge tank	Automatic level control fails to operate correctly	The surge tank is a partitioned tank with redundant surge lines. System surge capacity is provided to the unaffected portion of the tank, and system function is unaffected. The safety injection pumps cooling system performance is not affected.
Safety injection pumps cooling system surge tank	Pipe rupture in surge tank line connecting to pumps	The surge tank is divided in half by a partition, with two sources of water for pump suctions from two separate surge lines. The affected pipeline is isolated, and suction pressure maintained through the redundant surge line.

TABLE 9.2–13 CONSEQUENCES OF COMPONENT FAILURES – SAFETY INJECTION PUMPS COOLING SUBSYSTEM

Components	Malfunctions	Comments and Consequences
Electrically powered components, such as safety injection pumps cooling pumps, controls, power-operated valves	Failure of one power supply bus	Electrically powered components are separated and each separate group powered from a different emergency bus. One component cooling pump, its controls, and valves on one bus; another pump, controls, and valves are on a separate bus. The failure of one bus affects only that part of this redundant system, and system function will be unimpaired.

TABLE 9.2–14 CONDENSATE DEMINERALIZER COMPONENT COOLING WATER SYSTEM (3CCD) DESIGN DATA

Condensate Demineralizer Component	
Cooling Water Heat Exchangers (Removed from Service)	Data Summary
Design duty (Btu/hr)	26.5×10^6
Flow	
Component cooling water (gpm)	2,640
Seawater (gpm)	3,430
Cooling Water Pump (Removed from Service)	
Design flow	2,650
Design head (ft. of water)	112
DESIGN DATA FOR COMPONENTS COOLED BY 3CCD	
Regenerant Distillate Cooler (Removed from Service)	
Design duty (Btu/hr)	2.3×10^6
Component cooling water flow (gpm)	230
Regenerant Evaporator Condenser (Removed from Service)	
Design duty (Btu/hr)	22.7×10^6
Component cooling water flow (gpm)	2,260
Regenerant Evaporator Bottoms Cooler (Removed from Service)	
Design duty (Btu/hr)	63.8×10^4
Component cooling water flow (gpm)	130
Regenerant Evaporator Bottoms Sample Cooler (Removed from Service)	
Design duty (Btu/hr)	33×10^3
Component cooling water flow (gpm)	7.0
Auxiliary Condensate Sample Cooler (Removed from Service)	
Design duty	33×10^3
Component cooling water flow (gpm)	7.0

TABLE 9.2–15 DESIGN DATA FOR MAJOR COMPONENTS IN THE WATER TREATING SYSTEMS

Component	Equipment Number	Design Pressure (psig)	Design Flow (gpm each)
Water treating storage tank	3WTS-TK5	Atm	--
Carbon filters	WTS-FLT1A, B Abandoned	150	124
Cation demineralizers	3WTS-DEMN1A, B Abandoned	150	124
Anion demineralizers	3WTS-DEMN2A, B Abandoned	150	124
Mixed bed demineralizers	3WTS-DEMN3A, B Abandoned	150	124
Primary grade water deaerator	3WTS-DA1 Abandoned	125 (-29 in. vac)	30
Acid storage tank	3WTS-Tk2	Atm	--
Caustic storage tank	3WTS-Tk4	Atm	--
Acid measuring tank	3WTS-Tk1	Atm	--
Caustic measuring tank	3WTS-Tk3	Atm	--
Caustic dilution water heater	3WTS-E1 Abandoned	180	90
Water treating supply pumps	3WTS-P6A, B	154	240
Deaerator effluent pumps	3WTS-P7A, B Abandoned	76	30
Deaerator vacuum pumps	3WTS-P8A, B Abandoned	25 in. Hg abs.	60 acfm
Acid transfer pumps	3WTS-P2A, B	70	25
Caustic transfer pump	3WTS-P4A, B	70	25
Acid regenerant pumps	3WTS-P1A, B	900 (hydrotest)	1.65
Acid regenerant pumps	3WTS-P1C, D Abandoned	900 (hydrotest)	0.52
Caustic regenerant pumps	3WTS-P5A, B Abandoned	900 (hydrotest)	1.65
Caustic regenerant pump	3WTS-P5C Abandoned	900 (hydrotest)	0.31

TABLE 9.2–15 DESIGN DATA FOR MAJOR COMPONENTS IN THE WATER TREATING SYSTEMS (CONTINUED)

Component	Equipment Number	Design Pressure (psig)	Design Flow (gpm each)
Cleaning solution tank	3WTS-TK9	Atm	
pH solution tank	3WTS-Tk7	Atm	
Ultrafiltration cartridge filters	3WTS-FLT2A, B	150	265
Ultrafiltration module racks	3WTS-FLT3A, B	100	125
Permeate tank	3WTS-TK8	Atm	
Ultrafiltration supply pumps	3WTS-P10A, B, C	62	265
Ultrafiltration booster pumps	3WTS-P13A, B	31	132
Ultrafiltration flush pumps	3WTS-P14A, B	25	208
Contract Water Treatment Facility supply pumps	3WTS-P15A, B	128 (90 Max.)	124 (400 Max., 200 MP3)
Waste regenerant neutralizing sump	3WTW-Tk1	Atm	--
Waste regenerant sump pumps	3WTW-P1A, B	65	200
Acid neutralizing pump	3WTW-P2	50	1
Caustic neutralizing pump	3WTW-P3	50	1
pH adjustment/chemical feed pumps	3WTS-P12A,B	115	1.06
Cleaning solution pumps	3WTS-P11A,B	220	0.68
Water treating storage tank	3WTS-P9	27	60
Heater circulating pump			

TABLE 9.2–16 PRIMARY GRADE WATER SYSTEM MAJOR COMPONENT DESIGN DATA

		Design Data
1. Primary Grade Water Storage Tank		
	Number	2
	Design pressure (psig)	0
	Design temperature (°F)	150
	Design capacity (gal)	100,000 each
2. Primary Grade Water Storage Tank Heater		
	Number	2
	Design pressure (psig)	50
	Design temperature (°F)	100
	Design capacity (kW)	7
3. Primary Grade Water Heating Pump		
	Number	2
	Design pressure (psig)	350
	Design temperature (°F)	250
	Design capacity (gpm)	60
4. Primary Grade Water Supply Pumps		
	Number	2
	Design pressure (psig)	141
	Design temperature (°F)	100
	Design capacity (gpm)	225
5. Deaerator		
	Number	1
	Design pressure (psig) / Vacuum	100/30 in Hg
	Design temperature (°F)	200
	Design capacity (gpm)	200
6. Deaerator Supply Pump		
	Number	1
	Design pressure (psig)	150

TABLE 9.2–16 PRIMARY GRADE WATER SYSTEM MAJOR COMPONENT DESIGN DATA (CONTINUED)

		Design Data
	Design temperature (°F)	100
	Design capacity (gpm)	200
7. Deaerator Effluent Pump		
	Number	1
	Design pressure (psig)	150
	Design temperature (°F)	100
	Design capacity (gpm)	200
8. High Vacuum Steam Jet Ejector		
	Number	1
	Design pressure (psig)	150
	Design capacity (lb/hr)	125
9. Low Vacuum Steam Jet Ejector		
	Number	1
	Design pressure (psig)	150
	Design capacity (lb/hr)	75
10. Condensers		
	Number	2
	Design pressure (psig)	150
	Capacity, cooling water (gpm)	25
11 Condensate Pump		
	Number	1
	Design pressure (psig)	100
	Design temperature (°F)	600
	Capacity, intermittent (gpm)	1.25

TABLE 9.2–17 PRIMARY GRADE WATER CHEMISTRY SPECIFICATIONS

1.	Electrical Conductivity	Less than 2.0 μMhos/cm at 25°C
2.	pH	6.0 to 8.0
3.	Oxygen	Less than 0.10 ppm
4.	Chloride	Less than 0.15 ppm
5.	Fluoride	Less than 0.15 ppm
6.	Total Solids [1]	Less than 0.5 ppm
7.	Particulates	Filtered to less than 25 microns
8.	Silica	Less than 0.2 ppm
9.	Boric Acid [2]	Less than 10 ppm as boron
10.	Total Gamma Activity [2]	Less than 5 x 10^{-4} μCi/cc

NOTES:
1. Excluding boric acid
2. Only when transferring water from the Boron Recovery System

FIGURE 9.2–1 (SHEETS 1-4) P&ID SERVICE WATER

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.2–2 (SHEETS 1-3) P&ID REACTOR PLANT COMPONENT COOLING SYSTEM

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.2–3 (SHEETS 1-2) P&ID REACTOR PLANT CHILLED WATER SYSTEM

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.2–4 P&ID SAFETY INJECTION PUMP AND NEUTRON SHIELD TANK COOLING SYSTEMS

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.2–5 P&ID CHARGING PUMP SEALING AND LUBRICATION

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.2–6 P&ID CONDENSATE DEMINERALIZER LIQUID WASTE

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.2–7 (SHEETS 1-6) P&ID WATER TREATMENT SYSTEM

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.2–7(2)(A) (SHEETS 1-6) P&ID WATER TREATMENT SYSTEM (TEMP⁄MOD)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.2–7(5)(A) (SHEETS 1-6) P&ID WATER TREATMENT SYSTEM (TEMP⁄MOD)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.2–8 (SHEETS 1-3) P&ID DOMESTIC WATER AND SANITARY SYSTEMS

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.2–9 (SHEETS 1-3) P&ID CONDENSATE SYSTEM

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.2–10 (SHEETS 1-2) P&ID TURBINE PLANT COMPONENT COOLING WATER

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.2–11 P&ID PRIMARY GRADE WATER SYSTEM

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

9.3 PROCESS AUXILIARIES

9.3.1 COMPRESSED AIR SYSTEMS

This section describes the instrument air system, containment instrument air system, and service air system.

These air systems are not safety related, except for the portion of the instrument air and service air systems that penetrate the containment between the containment isolation valves.

Figure 9.3–1 is the piping and instrumentation diagram for the compressed air system.

9.3.1.1 Instrument and Service Air Systems

The instrument and service air systems are designed to provide sufficient compressed air of suitable quality and pressure for all instrumentation and controls and pneumatically operated tools.

9.3.1.1.1 Design Bases

The instrument and service air systems provide the following design features:

1. Normal plant instrumentation and service air requirements.

2. Three identical compressors, two instrument air compressors, and one service air compressor. To ensure reliability, each instrument air compressor has the capacity to supply 100 percent of the plant instrument air requirements. One of the instrument air compressors is powered from a Class 1E bus.

3. Each instrument and service air compressor is designed to deliver 750 scfm of air at a discharge pressure of 110 psig.

4. Two identical 100 percent capacity shutdown instrument air compressors. These compressors are powered from the orange and purple Class IE. The shutdown compressors can supply all air-operated valves inside containment and only those valves outside containment required for orderly cold shutdown. Each shutdown instrument air compressor is designed to deliver 150 scfm of air at a discharge pressure of 100 psig. These compressors are normally isolated and are not credited for accident mitigation or Loss of Power events.

5. Design temperatures of the instrument air distribution system are based on extreme ambient conditions. During normal plant operation, the instrument air aftercooler is capable of cooling the discharge air to 120°F.

6. The instrument and service air systems, are non safety-related except for the portion of the instrument air and service air systems that penetrates the containment between the containment isolation valves.

7. Automatic instrument air backup from the service air system.

8. Provision to connect a portable air compressor to the service air system.

9. Provision to connect a portable air compressor to the instrument air system.

To assure instrument air quality air dryers maintain the dew point at -40°F, redundant air filters remove 100 percent of all particle sizes above 1 micron and oil-free compressors minimize the oil content of the air. Inline moisture indicators are provided locally. The instrument air system also has a local inline moisture annunciator. Afterfilter differential pressure and trouble indicators and annunciators are provided locally and on the main control board, allowing operator action to correct any air quality deviation. Periodic air samples are analyzed for contamination during system operation.

9.3.1.1.2 System Description

Two oil-free instrument air compressors located in the turbine building normally provide instrument air for plant services. One operates on a load/unload mode, and one on a standby automatic mode. The instrument air compressor on the automatic mode starts if the instrument air system pressure falls below a preset minimum value. The instrument air compressor operating modes are reversed periodically to maintain uniform wear and verify proper component operability. One compressor is powered from a Class 1E bus.

One oil-free service air compressor, located in the turbine building, provides service air. The service air header is connected to the instrument air header to serve as backup for the instrument air system. On a low pressure signal from the instrument air system, a pressure control valve between the instrument and service air headers allows air to flow from the service air header to the instrument air headers.

The instrument air line penetrating the containment structure wall contains one air-operated valve located outside the structure and one motor-operated globe valve located inside the containment structure; these valves serve as containment isolation valves. Upon receipt of CIA signal both containment isolation valves close automatically.

The shutdown instrument air compressor header delivers air from the two shutdown air compressors located in the auxiliary building to the instrument air line penetrating the containment structure and to the headers outside the containment which are associated with orderly cold shutdown. These compressors are normally isolated and are not credited for accident mitigation or Loss of Power events.

The service air line penetrating the containment contains one locked closed valve outside the containment structure and one locked closed valve inside the containment which serve as containment isolation valves. Service air is provided for the makeup air method test of the containment leakage monitoring system (Section 6.2.6).

During routine maintenance of either instrument air compressor, instrument air aftercooler, or instrument air receiver, the service air system serves as a backup to the instrument air system. Also, there are capabilities to cross connect the Millstone 2 instrument air system which can be made up manually by inserting a flanged spool piece to permit the use of Millstone 2 instrument air. There is a permanent service air crosstie to Millstone 2 station air which can be manually aligned to serve as a backup.

Each compressor in the instrument air system and the service air system is furnished with an intake filter silencer, a water-cooled aftercooler, and air receiver. Instrument air may be used for breathing services on an infrequent basis at the utility's discretion.

Relief valves are provided on the instrument air receivers and on the lines upstream from the aftercoolers to prevent overpressurization of the air receivers and aftercoolers.

One hundred percent capacity water-cooled aftercoolers are provided for each instrument and service air compressor. One dual tower desiccant type instrument air dryer is provided for use during normal instrument air system operation. It includes two full capacity drying elements; one element is drying while the other is regenerating. A single tower nonregenerative desiccant dryer is provided as a backup when the dual tower dryer is out of service for maintenance. Afterfilters downstream of the instrument air dryers remove 100 percent of all particles above 1 micron.

Each shutdown air compressor is furnished with an intake filter silencer, a water-cooled aftercooler, and air receiver.

The shutdown air compressors are provided with their own individual dual tower desiccant type air dryer and afterfilters which remove 100 percent of all particles above 1 micron.

9.3.1.1.3 Safety Evaluation

The instrument and service air systems are non safety-related except for the containment isolation valves and the piping between. The isolation valves and associated piping are Safety Class 2. The remainder of the instrument and service air systems are designed non-nuclear safety (NNS).

The instrument and service air systems are not protected from earthquakes, flooding, tornadoes, missiles, or the effects of high and moderate energy pipe breaks, except for the piping between the containment isolation valves. The instrument and service air systems located close to safety related equipment are supported in such a manner that any failure will not preclude operation of safety related equipment.

The instrument air system is not required for safe shutdown. Instrumentation and controls for the following systems are designed such that control equipment fails in the safe mode upon loss of air:

1. Engineered safety features systems (Section 7.3).

2. Systems required for safe shutdown (Section 7.4).

3. All other instrumentation systems required for safety (Section 7.6).

The instrument air system is designed with the following features to assure instrument air quality is consistent with the operability requirements of air operated valves and instruments in safety related systems:

1. Air dryers which maintain the dewpoint at -40°F. An emergency dryer is available in the instrument air system in the event of servicing or of failure of one or both drying towers.

2. Redundant air filters which remove 100 percent of all particle sizes above 1 micron.

3. Oil-free compressors which minimize the oil content in the air.

4. In line moisture indicators are provided locally. The instrument air system also has a local inline moisture annunciator. Afterfilter differential pressure and trouble indicators and annunciators are provided locally, and on the main control board which assure system operation within the proper range and which allow operator action to correct any air quality deviation.

9.3.1.1.4 Inspection and Testing Requirements

9.3.1.1.4.1 Preoperational Testing of Instrument Air System

Preoperational testing of the instrument air system complies with Regulatory Guide 1.68.3 as discussed below:

The instrument air system is non safety-related, with the exception of the piping penetrating the containment boundary up to and including the isolation valves on either side of the penetration. This portion of the system is pressure tested to verify the integrity of the containment boundary.

The plant instrument air system has an interface with components that are part of safety related systems. These air controlled components were tested to verify that upon loss of their non safety-related air supply, they will respond by assuming their designed fail-safe position.

To verify that loss of the instrument air system will not affect any of the functions of the safety related systems, a loss of instrument air test was conducted at near normal operating temperature and pressure conditions.

9.3.1.1.4.2 Inservice Testing

During operation, periodic simulated low air pressure tests are performed on the instrument air system to ensure proper starting of the standby compressor when required. Other testing of the instrument air system is not required as they are normally in operation.

9.3.1.1.5 Instrumentation Requirements

The instrument air and service air system operating parameters are monitored, indicated, and controlled locally at the turbine building or remotely from the control room.

The following controls and instruments are located on the instrument and service air panel in the turbine building:

Control switches and indicating lights for:

1. Service air to instrument air valve
2. Domestic water and component cooling water valves
3. Service air supply valve

First-out annunciators on the instrument and service air panel in the turbine building that alarm when the following conditions exist:

1. Instrument air compressor cooling water temperature high
2. Instrument air compressor discharge air temperature high
3. Instrument air receiver pressure low
4. Instrument air compressor lube oil pressure low
5. Instrument air dryer afterfilter differential pressure high
6. Instrument air supply header pressure low
7. Instrument air aftercooler outlet air temperature high
8. Instrument air dryer discharge air moisture content high
9. Service air compressor water jacket temperature high
10. Service air compressor discharge air temperature high
11. Service air aftercooler outlet air temperature high

12. Service air header receiver pressure low
13. Service air compressor lube oil pressure low

The following instruments are located on the main board in the control room:

1. Indicating lights for the instrument air compressor, and the service air compressor
2. An indicator for instrument air supply header pressure
3. Annunciators that alarm when the following conditions exist:
    a. Service or instrument air trouble
    b. Instrument air compressor auto/trip
    c. Service air compressor breaker auto/trip or overcurrent

The following controls and instruments are located locally near the instrument and service air components:

1. Control switches for:
    a. Service air compressor
    b. Instrument Air Dryers
    c. Load transfer switch for the service air compressor
    d. Load transfer switch for the instrument air compressor
2. Local pressure and temperature indicators on the air compressors and aftercoolers, and local pressure indicators on the air receivers to monitor their operation
3. Instrument air dryer discharge air moisture content high indicator light
4. Indicating lights on the switchgear for the instrument air compressor feeder breaker and the service air compressor

The following parameters are monitored by the plant computer:

1. Instrument air compressor feeder breaker position
2. Instrument air compressor lube oil pressure low
3. Instrument air compressor cooling water temperature high

4. Instrument air compressor discharge air temperature high

5. Instrument air compressor supply header pressure

6. Service air compressor breaker position

The shutdown portion of the instrument air system's operating parameters are monitored, indicated, and controlled locally or remotely. The following instruments and controls are located on the main control board:

1. Shutdown instrument air compressor control switches and indicator lights

2. Shutdown air system isolation valve control switch and indicator lights

3. Shutdown instrument air header pressure indicator

4. Annunciators that alarm when the following conditions exist:

    a. Shutdown instrument air compressor cooling water temperature high

    b. Shutdown instrument air compressor discharge air temperature high

    c. Shutdown instrument air compressor lube oil pressure low

    d. Shutdown instrument air dryer afterfilter differential pressure high

    e. Shutdown instrument air supply header pressure low

The following controls and instruments are located locally near the shutdown instrument air system components:

1. Load transfer switches for the emergency instrument air compressors

2. Indicator for air dryer discharge air moisture content

3. Local pressure indicators on the shutdown instrument air receivers to monitor their operation

A shutdown instrument air header pressure indicator is provided on the auxiliary shutdown panel.

9.3.1.2 Containment Instrument Air System

The containment instrument air system uses the instrument air system to provide control air to instrumentation located within the containment boundary.

9.3.1.2.1 Design Bases

The containment instrument air system is designed to meet the following requirements:

1. The containment instrument air system is designed to provide air of suitable quality and pressure for reactor containment instrumentation.

2. The containment instrument air system is not safety related.

3. The containment instrument air system is continuously supplied air from the instrument air system.

9.3.1.2.2 System Description

The containment instrument air system is normally supplied by compressed air from the instrument air compressors.

Air from the instrument air system (Section 9.3.1.1.2) is continuously supplied to containment instrument air system, components inside the reactor containment. Air is normally supplied by the instrument air compressors.

9.3.1.2.3 Safety Evaluation

The containment instrument air system is not safety related. The containment instrument air system components are designed NNS.

The containment instrument air system is not protected from the effects of missiles or high and moderate energy pipe breaks because the containment instrument air system is not required for safe shutdown. The containment instrument air system located close to safety related equipment is supported in such a manner that any failure will not preclude operation of safety related equipment.

Instrumentation and controls for the following systems are designed such that control equipment fails in the safe mode upon loss of air:

1. Engineered safety features systems (Section 7.3)

2. Systems required for safe shutdown (Section 7.4)

3. All other instrumentation systems required for safety (Section 7.6)

Containment instrument air quality is consistent with the operability requirements of air-operated valves and instruments in safety related systems. The air quality is provided by the design of the instrument air system (Section 9.3.1.1.3).

The instrument air system normally provides air to the containment instrument air system as described in Sections 9.3.1.1.1 and 9.3.1.1.2.

9.3.1.2.4 Inspection and Testing Requirements

Preoperational testing was performed as described in Section 9.3.1.1.4.1.

During operation, periodic testing is performed as discussed in Section 9.3.1.1.4.2.

9.3.1.2.5 Instrumentation Requirements

Engineered safety features status lights are provided on the main board, one light to indicate when the containment instrument air supply pressure valve is closed and one light to indicate when the containment instrument air isolation valve is closed.

Computer inputs are provided to monitor the following system parameters:

1. Status of the containment instrument air supply pressure valve (open or closed)
2. Status of the containment instrument air isolation valve (open or closed)

A pressure indicator for containment instrument air supply pressure is also provided on the main board.

9.3.1.3 Diesel Instrument Air System

The diesel instrument air system is designed to provide sufficient compressed air of suitable quality and pressure for all instrumentation and controls. The diesel instrument air system connects to and is part of the instrument air system.

9.3.1.3.1 Design Basis

The diesel instrument air system provides the following design features:

1. One electric air compressor powered by a dedicated diesel generator to supply 100 percent of the plant instrument air requirements.
2. The compressor is capable of delivering 750 scfm of air at a discharge pressure of 110 psig.
3. The diesel instrument air system components are classified as non safety-related.
4. The system will automatically start on low instrument air system pressure.
5. The system can be manually started to supply instrument air when required.
6. The system has an emergency operation run time of 24 hours.

9.3.1.3.2 System Description

One oil-free air compressor located in the CPF that functions to provide a back-up supply of instrument air for plant services. The compressor is powered by a dedicated diesel generator located outdoors on the west side of the CPF. The diesel instrument air system will automatically start and supply instrument air if the normal instrument air system header pressure falls below a preset minimum value. This system has a heatless desiccant dryer and air receiver with a relief valve to prevent over pressurization.

The diesel instrument air compressor is a self-contained, air cooled unit, with its own control and monitoring system.

The diesel instrument air dryer is a dual tower, non-heated system that is self-contained, including its own control and monitoring system. The drying has a full capacity, manually operated, bypass line if the dryer becomes unavailable.

The diesel instrument air diesel generator is located outdoors on the west side of the CPF. The diesel generator supplies power only for the operation of the diesel instrument air system components.

The diesel instrument air receiver tank is an ASME Section VIII pressure vessel, located in the CPF.

9.3.1.3.3 Safety Evaluation

The diesel instrument air system components are designated NNS.

The diesel instrument air system is not protected from the effects of missiles or high and moderate energy pipe as the system is not required for safe shutdown.

9.3.1.3.4 Inspection and Testing Requirements

9.3.1.3.4.1 Preoperational Testing of the Diesel Instrument Air System

The diesel instrument air system components are non safety-related. This system connects to and is part of the instrument air system. The system is pressure tested up to the point of connection to the existing station instrument air system. The system is functionally tested to ensure all components will perform their intended functions.

9.3.1.3.4.2 lnservice Testing

During operation, periodic simulated low air pressure tests are performed on the diesel instrument air system to ensure proper starting of the diesel generator, air compressor and air dryer to verify the ability to supply air to the instrument air system.

9.3.1.3.5 Instrumentation Requirements

The diesel instrument air system operating parameters are monitored, indicated and controlled locally in the CPF or remotely indicated in the Unit 3 Control Room.

The following controls and instruments are located on the diesel instrument air system control panel in the CPF or outdoors on the diesel generator skid.

1. System control and indication panel

   a. System control - Off - Manual - Auto

2. Diesel generator control and indication panel

3. Air compressor control and indication panel

4. Air dryer control and indication panel

5. Local pressure indication on the receiver tank

6. Pressure switch for system pressure monitoring and system activation.

The following indication is located on the main control board in the Unit 3 Control Room.

1. Two indicating lights are located on the main control board to provide status of the diesel instrument air system.

The diesel instrument air system is not monitored by the plant process computer.

There are no main control board annunciators for the diesel instrument air system.

9.3.2 PROCESS SAMPLING SYSTEMS

The sampling system consists of two systems - reactor plant sampling system (SSR) and turbine plant sampling system (SST).

9.3.2.1 Design Bases

The design bases for the reactor and turbine plant sampling systems are:

1. Representative samples from process streams or tanks in accordance with Regulatory Guide 1.21.

2. Representative samples from gaseous process streams and tanks in accordance with ANSI N13.1 - 1969 and Regulatory Guide 1.21.

3. Remote-operated isolation valves designed to fail closed on all sample lines coming from systems which are classified as nuclear safety related.

4. All sample streams that are not purged directly to their corresponding sample sink will either be reclaimed to the origin or flow to their corresponding floor drain sumps.

5. Flow restrictions in the following lines, limiting reactor coolant loss from a rupture of the sample line SSR lines: pressurizer vapor space, reactor coolant hot legs, reactor coolant cold legs, and the steam generator blowdown line. SST lines: main steam, first point feedwater heater, and condenser hotwell lines.

6. Sample lines are adequately purged before a sample is collected to ensure that a representative sample is obtained.

7. The following ASME code classes and safety classes apply:

   a. The sampling lines from the steam generator blowdown lines, safety injection accumulators, reactor coolant hot and cold legs, and pressurizer, up to and including the outermost containment isolation valves, are designed in accordance with ASME III, Class 2, and are classified Safety Class 2. The sample line from the pressurizer relief tank is ASME III, Class 2, and Safety Class 2 only at the penetration.

   b. Sampling lines connected to Safety Class 2 and 3 systems, up to and including the solenoid-operated isolation valve, as indicated on Figure 9.3–2 are designed in accordance with ASME III, Class 2 and 3, respectively, and are classified Safety Class 2 and 3, respectively.

   c. All other sampling lines are designed to ANSI B31.1 and are classified nonnuclear safety (NNS).

8. Sample coolers are provided to reduce sample temperatures to 150°F or less for safe handling.

9. All of the SSR lines that penetrate the containment are provided with containment isolation valves in accordance with General Design Criteria 55, 56, and 57.

10. The following portions of the reactor plant sampling system either perform a safety function or maintain their integrity for pressure boundary isolation purposes following a safe shutdown earthquake, and therefore meet Seismic Category I design requirements:

    a. Sampling lines upstream of the outside containment isolation valve, except for the pressurizer relief tank sample line. For this line, the containment penetration and isolation valves only are Seismic Category I.

b. Sampling lines upstream of the solenoid-operated isolation valves in the sampling lines from the residual heat removal system and chemical and volume control system.

c. All valves used for isolation at these safety class transitions.

d. The portion of the hydrogenated liquid purge header interfacing with the chemical and volume control system downstream of and including the check valve.

e. All instrumentation and controls which perform a containment isolation function.

These portions of the system are protected from missiles and tornado winds.

The remaining portions of the reactor plant sampling system have no seismic or tornado design requirements except that their failure does not cause a loss of function of any safety related equipment or personnel injury.

The turbine plant sampling system has no seismic design requirements.

9.3.2.2 System Description

The reactor and turbine plant sampling systems (Figures 9.3–2 and 9.3–3, respectively) have the capability for sampling all normal process systems and principal components listed in Tables 9.3–1 and 9.3–2.

The reactor plant remote samples are taken at sample sinks located in the auxiliary and waste disposal buildings. The remote turbine plant samples are taken at the sample sink located in the turbine building.

The reactor plant sampling lines coming from within the containment structure, except for the pressurizer relief tank gas space sample and the safety injection accumulator samples, are high temperature samples. Each reactor plant sampling line, except the steam generator blowdown sample lines, and some sampling lines originating outside the containment structure, have solenoid-operated selection valves in their lines that are operated remotely from their respective sample sinks in the auxiliary or the waste disposal building. The turbine plant sample lines have manual selection valves except for the condenser hotwell sample lines which have remote sequenced valves.

Each reactor plant sampling line penetrating the containment structure, except the steam generator blowdown lines, has three remote operated solenoid isolation valves:

> A sample isolation and a containment isolation valve inside containment and a containment isolation valve outside containment. The steam generator blowdown sampling lines have one remotely operated isolation valve outside containment.

The containment isolation valves close automatically on a containment isolation (CIA) signal. The steam generator blowdown sample line isolation valves automatically close whenever a sequenced safeguard signal (CDA, SIS, or LOP), an auxiliary feedwater pump auto start signal (any steam generator 2/4 low-low level), or an AMSAC actuation signal is present. Each sampling line isolation valve can be opened and closed by an individual switch on the main control board. A CIA signal overrides the manual signal to the containment isolation valve from the switch on the main control board.

The reactor plant sample sinks have ventilation hoods with fans and carbon absorbers in the exhaust duct, which protect operating personnel and prevent the spread of radioactive contamination. The turbine plant sample sink has a hood with an exhaust fan.

High temperature sample lines are provided with sample coolers which cool the high temperature samples to a temperature low enough for safe handling (150°F or less). Pressure regulators are provided to reduce the pressures of high pressure lines to no more than 25 psig for normal liquid samples in each sample line. High pressure samples are taken at or near system operating pressures. After sufficient purging, a pressurized sample is obtained by isolating the sample in a sample capsule and removing the capsule from the sample line for analysis.

The purge flows of the various samples in the reactor and turbine plant sampling systems are discharged to systems as shown on Figures 9.3–2 and 9.3–3.

The Reactor Plant and Turbine Plant systems provide continuous radiation monitoring of various streams, as well as continuous monitoring of those parameters required by the EPRI PWR Secondary Water Chemistry Guidelines. Each sampling system is operated manually on an intermittent basis, except where continuous sampling is provided, during conditions ranging from full power operation to cold shutdown.

Local instrumentation at the sample sinks permits manual control of sampling operations and ensures that the samples are at suitable temperatures and pressures before diverting the flow to the sampling sinks. Each purge header contains a flow indicator to indicate if the flow is sufficient to obtain a representative sample.

9.3.2.3 Safety Evaluation

The systems are designated NNS, except for those portions of the sampling lines that are inside and penetrate the containment, including their isolation valves, and those lines that connect to a safety class (SC-2 or SC-3) system, which are designated SC-2 or SC-3, respectively. The primary system sample line containment isolation valves close on receipt of a CIA signal. The steam generator blowdown sample line isolation valves automatically close whenever a sequenced safeguard signal (CDA, SIS, or LOP), an auxiliary feedwater pump auto start signal (any steam generator 2/4 low-low level), or an AMSAC actuation signal is present. The sampling systems are designed in accordance with standard industrial practice and do not jeopardize or interfere with the operation of any safety system. If a critical sampling line, i.e., reactor coolant, becomes inoperable because of a malfunction, at least one alternate path exists which can be used to obtain a similar sample. For example, if the reactor coolant cold legs sampling line becomes inoperable, the reactor coolant hot legs sampling line is used as an alternate.

All samples having an operating temperature greater than 150°F are cooled to below 150°F for safe handling.

All grab samples and continuous samples are reduced in pressure to 150 psig or below before being sampled.

9.3.2.4 Inspection and Testing Requirements

Most components are used regularly during power operation and shutdown, ensuring the availability and performance of the sampling systems. Monitors that operate continuously are periodically tested, calibrated, and checked to ensure proper instrument response and operation of alarms.

Safety class valves in the system require testing as specified in Section 6.2.4.

9.3.2.5 Instrumentation Requirements

Sampling instrumentation is located adjacent to the sample sink.

Local temperature indicators, at the outlet of the high temperature sample coolers and the constant temperature bath, measure sample temperature prior to sample collection.

Local pressure indicators downstream from the high pressure throttling valves and pressure reducing valves permit the adjustment of these valves.

Local flow indicators monitor sample flow rates.

Relief valves protect sample coolers and sample lines from overpressure.

Remote control switches and indicator lights are located on the main control board for manual operation of sample line isolation valves. Primary system sample line containment isolation valves are closed automatically on receipt of a CIA signal. The steam generator blowdown sample line isolation valves automatically close whenever a sequenced safeguard signal (CDA, SIS or LOP), an auxiliary feedwater pump auto start signal (any steam generator 2/4 low-low level), or an AMSAC actuation signal is present. Alarms and annunciators indicate adverse conditions on the sample panels. Also, an annunciator is alarmed on main control board when the following condition exists: steam generator blowdown sample isolation valve reset.

9.3.2.6 Post-Accident Sampling System

The post-accident sampling system (Figure 9.3–10) is nonnuclear safety related (NNS).

9.3.2.6.1 Design Bases

The design bases for the post-accident sampling system are:

1. Collecting primary coolant or sump liquid samples for analysis.

2. Isolating samples of the containment air for analysis.

3. Containment penetration piping and isolation valves along with interface piping and valves to reactor plant sampling lines are Safety Class 2. Containment isolation valves are designed to fail closed. All other piping and components are designed NNS and nonseismic.

4. Amendment 201 eliminated the requirements to have and maintain the post-accident sampling program (PASS). The ability to obtain and analyze post-accident samples of the reactor coolant and containment atmosphere are no longer a required activity and were removed from Section 12.3.1.3.2.

Amendment Number 201 to the operating license eliminated the requirements for PASS in the Technical Specifications and PASS specific requirements imposed by post-TMI confirmatory orders. However, if radiological conditions permit, post accident samples can be obtained and analyzed based on the recommendations of the Emergency Response Organization.

9.3.2.6.2 System Description

The post-accident sampling system has the capability of obtaining samples from the following:

1. Primary coolant from the four reactor coolant cold legs and the two reactor coolant hot legs via connections to the reactor plant sampling lines when RCS pressure is $>$ 240 psig.

2. A representative containment air sample via the hydrogen recombiner intake lines.

3. Sump liquid samples from the containment recirculation sump, via the recirculation spray lines.

The liquid and air samples are sent to the hydrogen recombiner building where the post-accident sampling module units are located. The motive force for obtaining reactor coolant samples is the differential pressure between the primary reactor loop and the liquid sample module. The containment recirculation spray pumps supply the liquid sample module with a containment floor liquid sample. A bellows pump located in the hydrogen recombiner building supplies a representative containment air sample to the air sample module via the hydrogen recombiner suction piping.

Each post-accident sampling line used for obtaining a primary coolant sample or a sump liquid sample has a solenoid-operated selection valve that is operated remotely from a control panel in the hydrogen recombiner building. The post-accident containment air sampling lines have manually-operated valves at the interface with the hydrogen recombiner lines in the hydrogen recombiner building. These manual valves are operated by reach rods from a shielded area in the hydrogen recombiner building.

One post-accident sampling line supplying primary coolant or a containment sump liquid sample, and one return line to the containment penetrate the containment structure. Each line penetrating the containment structure has one automatic, solenoid-operated isolation valve inside containment and one locked closed manually-operated isolation valve outside containment. The automatic containment isolation valves close automatically on a containment isolation (CIA) signal.

The reactor coolant post-accident sampling system and containment air post-accident sampling system are each dual module units consisting of one sample module and one remote-operated module.

Prior to entering the post-accident sampling module the liquid is cooled in the reactor coolant module cooler to acceptable temperatures (165°F or less). The reactor coolant sample module is designed to a pressure of 2500 psig.

Both the reactor coolant sample module and the containment air sample module cabinets have an exhaust blower that discharges into the supplementary leak collection system. The sample module ventilation system exhausts at a nominal design flow of 100 cfm to establish a minimum capture velocity of 50 fpm into the sample modules with one panel door in the open position.

Samples to be analyzed off site are collected in a 2-ml shielded, removable sample chamber within the sample module. The sample may be either pressurized at primary system pressure or unpressurized (less than 70 psig). Radiological analysis can identify and quantify isotopes on site in the range from approximately 10 μCi/ml to 10 Ci/ml.

The accuracy, range, and sensitivity are adequate to provide pertinent data to the operator in order to describe the radiological status of the reactor coolant system.

The post-accident sample lines and equipment are purged after the sample is obtained. A flushing module is provided to purge the liquid sample system with demineralized water. The flushing module consists of a 30 gallon water storage tank and a positive displacement pump. The flushing module also contains a pressurized nitrogen supply with an auxiliary supply from the permanent plant nitrogen system (Section 9). The nitrogen supply is used to purge the dissolved gases in the liquid sample system and to purge the containment air sample system. The liquid sample system is purged to the volume control tank via the reactor coolant pump seal injection return line. The liquid purge may also be directed to the containment drain sump. The containment air sampling system can be purged back to the containment via the hydrogen recombiner discharge piping.

9.3.2.6.3 Safety Evaluation

Except for the portion of post-accident sampling lines that penetrate the containment, including the isolation valves, and the solenoid valves and piping interfacing with the safety related sampling piping within containment, the post-accident sampling system is not safety related.

Redundancy is designed into the system to obtain a reactor coolant liquid sample or a containment air sample. A reactor coolant liquid sample can be obtained from any of the four cold legs or from the two hot legs of the primary coolant system. Thus, if one of the sampling lines becomes inoperable because of a malfunction, there is an alternate sample path. Likewise, a containment air sample can be obtained from either of two redundant hydrogen recombiner supply lines.

9.3.2.6.4 Inspection and Testing Requirements

System solenoid valves are cycled periodically to ensure functionality and availability.

9.3.2.6.5 Instrumentation Requirements

The post-accident sampling system inside containment isolation valves have control switches and indicator lights on the main control board. The open and close positions are monitored by the plant computer. Engineered safety features status lights on the main control board indicate when the post-accident sampling system inside containment isolation valves are open. The isolation valves are closed automatically on receipt of a CIA signal.

Control switches and indicator lights are located on a panel in the hydrogen recombiner building for control of the individual sample valves.

The sample containment air sample pump has controls for manual operation from a panel in the hydrogen recombiner building.

The containment air sample module is operated from the containment air sample remote panel and the reactor coolant module is operated from the reactor coolant remote panel in the hydrogen recombiner building.

9.3.3 REACTOR PLANT VENT AND DRAIN SYSTEMS

The reactor plant vent and drain systems collect waste gases and liquids from valve and pump leakoffs, tank drains, and other equipment and floor drains containing radioactive contamination, and transfer them to the gaseous and liquid waste systems for treatment and/or disposal. These systems consist of the reactor plant gaseous vent system, the reactor plant aerated vent system, the reactor plant gaseous drain system, and the reactor plant aerated drain system (Figures 9.3–4 through 9.3–6, respectively).

9.3.3.1 Design Bases

The reactor plant vent and drain systems are non safety-related, except for the lines penetrating the containment structure and the three safety related sumps located in the Engineered and Safety Features Building. Two of the three sumps (3DAS*SUMP7A & B) collect miscellaneous equipment drainage. The third sump is the porous concrete groundwater sump that collects groundwater that has circumvented the waterproof membrane that surrounds the containment structure and containment structure contiguous buildings. For containment penetration areas, isolation valves on both sides of the containment structure wall and the piping between them are Safety Class 2.

The gaseous vent system handles vents where hydrogen and radioactive gases predominate, while the aerated vent system handles vents where air predominates. These vent systems flow separately to the radioactive gaseous waste system (Section 11.3).

The gaseous drain system handles drains containing nonaerated reactor coolant. These drains may be directed to the radioactive gaseous waste system for degasification and return to the reactor coolant system (Chapter 5) via the chemical and volume control system (Section 9.3.4). Alternately the drains may be directed to the Boron Recovery System (Section 9.3.5). The aerated drain system handles drains containing air and flows to the radioactive liquid waste system (Section 11.2).

9.3.3.2 System Description

9.3.3.2.1 Reactor Plant Gaseous Vents System

Gaseous vents (Figure 9.3–4) are vented during normal operation from the containment drains transfer tank (Figure 9.3–5), pressurizer relief tank (Chapter 5), primary drains transfer tank (Figure 9.3–5), volume control tank (Section 9.3.4), and reactor plant sampling hydrogenated gaseous purge header (Figure 9.3–2). The radioactive gaseous waste system process effluent gas is discharged to the gaseous vents system header. These vents are transferred by the gaseous vent system to the radioactive gaseous waste system.

9.3.3.2.2 Reactor Plant Aerated Vents System

Aerated vents (Figure 9.3–4) from the following tanks, condenser, and container in the boron recovery system (Section 9.3.5), radioactive liquid waste system (Section 11.2), and radioactive solid waste system (Section 11.4) are transferred by the aerated vent system to the radioactive gaseous waste system (Section 11.3): boron recovery tanks, boron distillate tank, boron evaporator condenser, waste distillate tank, high level waste drain tanks, waste bottoms hold tank, low level waste drain tanks, spent resin dewatering tank, disposable waste shipping container. The waste distillate tank and waste bottoms hold tank are no longer used.

9.3.3.2.3 Reactor Plant Gaseous Drains System

Gaseous drains (Figure 9.3–5) originate from systems containing reactor coolant or from systems which potentially could contain reactor coolant and are collected in the pressurizer relief tank, the containment drains transfer tank, and the primary drains transfer tank.

The pressurizer relief tank is located in the containment structure and receives gaseous drains from the pressurizer safety valves (Section 5.4.11).

The containment drains transfer tank is located inside the containment structure and collects gaseous drains from valve stem leakoffs, reactor vessel flange leak detection line (Section 5.2.5), and from the safety injection accumulator tanks (Section 6.3). The reactor coolant loops can be drained to the containment drains transfer tank directly or via the excess letdown heat exchanger in the chemical and volume control system.

The primary drains transfer tank is located in the auxiliary building (Section 3.8.4) and receives drains from the reactor plant sampling system hydrogenated contaminated liquid purge header (Figure 9.3–2); valve stem leakoffs outside the containment structure; relief valve discharges from the radioactive gaseous waste system, chemical and volume control system, and high and low pressure safety injection systems (Chapter 6); and drains from the volume control tank.

The containment drains transfer tank, pressurizer relief tank, and primary drains transfer tank each has two full capacity drain transfer pumps to transfer gaseous drains to the degasifier recovery exchangers (Figure 11.3–1) in the radioactive gaseous waste system or the cesium removal ion exchangers (Figure 9.3–9) in the boron recovery system. The pumps are started manually and stopped automatically.

9.3.3.2.4 Reactor Plant Aerated Drains System

Aerated drains are collected in sumps located inside the containment structure (incore instrument room sump, unidentified leakage sump, and containment drains sump); Engineered Safety Features Building (two residual heat removal cubicle sumps, two containment recirculation cubicle sumps, and Engineered Safety Features Building sump); auxiliary building; pipe tunnel; fuel building; waste disposal building (two sumps); and turbine building (two turbine plant component cooling drain sumps and turbine building floor drain sump).

The aerated drain system also contains four underdrain sumps. Three of these sumps collect drainage from under the Engineered Safety Features, Fuel, Waste Disposal, Auxiliary, Service and Control Buildings. The uncontaminated effluent from these sumps is pumped directly to the yard storm sewer system. The fourth underdrain sump is located in the basement of the Engineered Safety Features Building. This sump collects groundwater that has circumvented the waterproof membrane that was installed around the Containment Structure and the Containment Structure contiguous buildings. The effluent from this sump is pumped to a storage tank in the yard. The effluent is not radiologically contaminated, but the groundwater has a high pH and is treated as necessary to achieve effluent limits prior to discharge. There is no connection between the underdrain sumps and the contaminated section of the aerated drains system.

The contaminated portion of the aerated drains system includes several sumps. Except for the containment drains sump, these sumps collect aerated drains from equipment, filters, and the floor drains in their respective areas. The containment drains sump collects aerated drains directly from equipment and systems inside the containment structure. Depending on the activity level, all aerated drains except the turbine building floor drain sump are transferred by sump pumps through either the high or low level waste drain header (Figure 9.3–6) to the high or low level waste drain tank, respectively (Figure 11.2-1) in the radioactive liquid waste system.

The turbine building floor drain sump is monitored for radioactivity. It is normally pumped to the yard drainage system, but is directed to the liquid radioactive waste system via the turbine plant component cooling drain sump on a predetermined radioactivity level.

The neutron shield tank cooling system (Section 9.2.2.3) uses potassium dichromate as a corrosion inhibitor. Whenever this system is drained to the containment drains sump, the sump is pumped directly, under administrative control, to the high level waste drain header. Drainage from the radioactive solid waste system (Figure 11.4–1) flows directly to the high level waste drain header.

9.3.3.2.4.1 Safety-Related Porous Concrete Groundwater Sump (Underdrain System Sump)

The porous concrete groundwater sump is located in the Engineered Safety Features Building. This sump collects (via an underdrain and porous concrete media) any significant amount of groundwater seepage which has circumvented the waterproof membrane. The sump is equipped with a non-safety related electric sump pump. The sump protects the containment steel liner from hydrostatic loading. It is sized such that using a design basis seepage of approximately 2200 gallons per day, 32 hours are available to replace a failed non-safety related electric sump pump and restore the groundwater removal capability of the sump pump. The sump pump transfers groundwater collected in the sump to a tank in the yard. Sampling and pH treatment is performed as necessary on the tank contents prior to discharge. The sump pump is accessible via the Engineered Safety Features Building roof and is outside the SLCRS boundary (i.e., the sump pump can be removed and installed from the roof). The electric sump pump is powered by non-safety related electrical circuits which derive power from a safety related electrical bus (see Table 8.3–3). Utilizing a safety related power source to provide power to the non-safety related pump provides greater assurance of a reliable energy source. A spare sump pump is stored on site. Administrative controls are in place to monitor the groundwater inleakage and the non-safety related electric pump operability. Administrative controls include monitoring of the non-safety related pump start and stop times, the water level of the porous concrete groundwater sump and the water level of the tank in the yard.

9.3.3.2.5 Containment Isolation Valves

Containment isolation valves are provided in all lines penetrating the containment structure (Section 6.2.4). Both containment isolation valves in the gaseous vents system are open during normal operation. During normal operation for both the gaseous and aerated drains systems, the containment isolation valve inside the containment structure is closed and the one outside the containment structure is open. A containment isolation, phase A (CIA) signal overrides all other signals and closes the containment isolation valves.

9.3.3.3 Safety Evaluation

The reactor plant vent and drain systems are designed and sized to handle the maximum flow rate of vents and drains expected during unit operation.

Austenitic stainless steel piping and tubing is used to transfer all fluids in the reactor plant vent and drain systems.

The containment drains transfer pumps, pressurizer relief tank drains transfer pumps, and primary drains transfer pumps drain their respective tanks in the reactor plant gaseous drain system. Two pumps are provided for each tank. The pumps are started manually and stop automatically.

On receipt of a high level alarm for the containment drains transfer tank or the primary drains transfer tank, one of the pumps associated with the alarming tank is started by remote manual control. If the level does not decrease, the second pump is started remote manually. The pumps are stopped automatically on receipt of the tank low level signal.

Upon receipt of the pressurizer relief tank high level alarm, the normally closed air-operated valve in the suction line from the pressurizer relief tank to the pressurizer relief tank drains transfer pumps is opened remote manually and one of the pumps is started remote manually. If the level does not decrease, the second pump is started remote manually. The pressurizer relief tank drains transfer pumps stop automatically on receipt of a pressurizer relief tank low level signal. The air-operated valve in the suction line to the pumps is closed remote manually.

A CIA signal closes the containment isolation valves in the reactor plant gaseous drain system, which stops the pressurizer relief tank drains transfer pumps and containment drains transfer pumps. This CIA signal terminates any potential radioactive release from containment by this pathway.

A duplex pump arrangement is provided for each of the following reactor plant aerated drains system sumps (Figure 9.3–6): containment drains sump, turbine building floor drain sump, auxiliary building sump, fuel building sump, two waste disposal building sumps, and three underdrain sumps. With the exception of the turbine building floor drain sump, one pump is in automatic service and the other on standby, and each pump is independently controlled. When the water level in a sump reaches a specified height, the associated sump pump starts automatically. If the water in the sump reaches a specified higher level, the associated standby sump pump also starts automatically. The sump pumps stop automatically when the water has decreased to a specified level in the associated sump. A CIA signal closes the containment isolation valves in the reactor plant aerated drain system, which stops the containment drains sump pumps terminating any potential radioactive release from containment by this pathway.

The turbine building floor drain sump pumps are provided with auto start signals at pre-defined time intervals.

Single pumps are provided in the following sumps (Figure 9.3–6): incore instrument room sump, unidentified leakage sump, two turbine plant component cooling drains sumps, pipe tunnel sump, two residual heat removal cubicle sumps, two containment recirculation cubicle sumps, and engineered safety features building sump. Each pump starts automatically when the water level in the associated sump reaches a specified level, and stops when the level drops to a specified level. Alarms are activated if the level rises above a specified level, except for the unidentified leakage sump. The unidentified leakage sump alarm (KA) initiates if P10 restarts too soon after stopping or if P10 runs too long. The frequency of operation of the unidentified leakage sump pump is monitored as one method of detecting excess leakage inside the containment structure (Section 5.2.5).

In addition to the pumps described above, the Engineered Safety Feature Building (ESFB) is equipped with a non-safety related sump pump to remove groundwater that has circumvented the waterproof membrane surrounding the Containment Structure and the Contain Structure contiguous buildings. The pump is credited with groundwater removal during normal operation, following a LOCA and during loss of normal power scenarios. The ESFB roof is accessible after 24 hours post LOCA with respect to radiation. The single non-safety related sump pump design is acceptable because the sump pump is accessible from the ESFB roof and sufficient time is available to perform maintenance activities for the pump without overfilling the sump and without compromising safety related structures, systems or components. A spare sump pump is stored on site.

The residual heat removal cubicle sumps and pumps are located in safety related areas, although they are not safety related themselves. The cubicles are completely separate from one another. Furthermore, drain piping is run to an elevation high enough to prevent back flooding from the engineered safety feature building back to these cubicles. The other pumps are in non safety-related areas.

All lines in the systems penetrating the containment structure have two containment isolation valves in series (Figure 9.3–4 through 9.3–6). The power to each solenoid-operated pilot valve for the redundant containment isolation valves is supplied from a separate emergency bus. All of these containment isolation valves fail closed on loss of actuating air, loss of actuating signal, or loss of power.

When systems or components containing potassium dichromate are drained, the liquid is processed per applicable hazardous waste procedures which ensure that the drained potassium dichromate inhibitor is not released to the environment.

9.3.3.4 Tests and Inspections

Periodic testing of the reactor plant vent and drain systems is not necessary because they are used in normal operation. Inspection is performed in accordance with normal maintenance procedures. Containment isolation valves are tested in accordance with the procedures in Section 6.2.4.

The safety related Engineered Safety Feature Building (ESFB) sump and associated non-safety related sump pump were tested after installation to confirm the system’s capability to remove the accumulated groundwater from the sump. The testing also confirmed that the ESFB basement area is water tight up to an elevation that is equal to the top of the safety related sump. The sump is qualified for seismic loading and post accident conditions and performance testing was conducted to confirm that the subsystem would operate as required post LOCA.

9.3.3.5 Instrumentation Requirements

9.3.3.5.1 Reactor Plant Gaseous Vent System

The reactor plant gaseous vent system operating parameters are monitored, indicated, and controlled, locally or remotely as follows:

Main Control Board

1. The main control board has pushbuttons with open and close indicating lights for the inside and outside containment isolation valves in the reactor plant gaseous vent system.

2. Status windows monitor the inside and outside containment isolation valves, in reactor plant gaseous vent system, closed position.

3. Computer inputs are for the inside and outside containment isolation valves, in the reactor plant gaseous vent system, open and closed positions.

A pressure control valve, located in the reactor plant gaseous vent system discharge line to the condenser air removal system, maintains back pressure in the line. A local pressure indicator is provided in the reactor plant gaseous vent system discharge line.

9.3.3.5.2 Reactor Plant Aerated Vent System

No instrumentation is associated with this system.

9.3.3.5.3 Reactor Plant Gaseous Drain System

The reactor plant gaseous drain system operating parameters are monitored, indicated, and controlled, locally or remotely as follows:

Main Control Board

1. The main control board has pushbuttons with open and close indicating lights for the following valves:

    a. Pressurizer relief tank drains outlet valve

    b. Gaseous drains inside and outside containment isolation valves

2. The main control board has a BLOCK-AUTO pushbutton for the pressurizer relief tank drains outlet valve to override auto control of the valve.

3. The main control board has control switches with start and stop indicating lights for the following pumps:

   a. Pressurizer relief tank drains transfer pumps

   b. Primary drains transfer pumps

   c. Containment drains transfer pumps

4. Annunciators monitor the following conditions:

   a. Pressurizer relief tank drain valve OVERRIDE

   b. Pressurizer relief tank water level, High-High/High/Low

   c. Gaseous drain system outside containment pressure, High

   d. Containment drains transfer tank water level, High/Low

   e. Containment drains transfer tank water level, High-High

   f. Primary drains transfer tank water level, High/Low

   g. Primary drains transfer tank water level, High-High

   h. Reactor vessel flange leakoff temperature, High

   i. Reactor plant drains to boron recovery system temperature, High

5. Indicators monitor the following:

   a. Pressurizer relief tank water level

   b. Gaseous drain system outside containment pressure

   c. Containment drains transfer tank pressure

   d. Containment drains transfer tank water level

   e. Reactor vessel flange leakoff temperature

   f. Primary drains transfer tank water level

6. Status windows monitor the following:

   a. Gaseous drains inside containment isolation valve, open

   b. Gaseous drains outside containment isolation valve, closed

7. The plant computer inputs from this system are:

   a. Pressurizer relief tank water level

   b. Gaseous drain system outside containment pressure

   c. Gaseous drains inside containment isolation valve, open

   d. Gaseous drains inside containment isolation valve, closed

   e. Gaseous drains outside containment isolation valve, open

   f. Gaseous drains outside containment isolation valve, closed

   g. Containment drains transfer tank water level

   h. Primary drains transfer tank water level

   i. Pressurizer relief tank drains transfer pumps total flow

   j. Primary drains transfer pumps total flow

   k. Containment drains transfer pumps total flow

8. Local pressure indicators indicate pressure at the following locations:

   a. Containment drains transfer tank inlet

   b. Pressurizer relief tank drains transfer pumps discharge lines

   c. Containment drains transfer pumps discharge line

   d. Primary drains transfer pumps discharge lines

9.3.3.5.4 Reactor Plant Aerated Drain System

The reactor plant aerated drain system operating parameters are monitored, indicated, and controlled, locally or remotely as follows:

<u>Main Control Board</u>

1. The main control board has pushbuttons with open and close indicating lights for the inside and outside containment drains isolation valves

2. Annunciators monitor the following conditions:

    a. Radioactive liquid waste system trouble

    b. Safeguards area flooding

3. Indicating lights indicate the following:

    a. Pipe tunnel floor water level High

    b. Emergency core cooling system pipe cubicle floor water level High

    c. Residual heat removal cubicle floor water level High

    d. Containment recirculation cubicle floor water level High

4. Computer inputs are for the following:

    a. Incore instrument sump pump discharge pressure

    b. Incore instrument room sump pump stopped

    c. Incore instrument room sump pump running

    d. Auxiliary building sump pump running

    e. Auxiliary building sump pump stopped

    f. Containment drains sump pump running

    g. Containment drains sump pump stopped

    h. Engineered safety features building sumps total flow

    i. Inside containment drains isolation valve open

    j. Inside containment drains isolation valve closed

    k. Outside containment drains isolation valve open

    l. Outside containment drains isolation valve closed

    m. Containment drains sump 3 level

n. Containment drains sump discharge total flow

o. Residual heat removal cubicle sump pump running

p. Residual heat removal cubicle sump pump stopped

q. Containment unidentified leakage sump 2 level

r. Containment unidentified leakage sump pump running

s. Containment unidentified leakage sump pump stopped

t. Turbine building floor drain sump pump running

u. Turbine building floor drain sump pump stopped

5. Status windows monitor the following:

   a. Inside containment drains isolation valve open

   b. Outside containment drains isolation valve closed

<u>Liquid Waste Panel</u>

1. The liquid waste panel has control switches and indicating lights for the following pumps:

   a. Core instrument room sump pump

   b. Containment drains sump pumps

   c. Containment unidentified leakage sump pump

2. A lead-follow selector switch for the containment drains sump pumps, (3DAS-P2A, 3DAS-P2B).

3. First-out annunciators monitor the following conditions:

   a. Fuel building sump level High-High

   b. Incore instrument sump 1 level high-high

   c. Under drain sumps 1, 2 and 3 level High-High

   d. Auxiliary building sump 5 level High-High

e. ESF building sump 10 level High-High

f. Containment drains sump 3 level High-High

g. Turbine plant component cooling drain sumps 11A & B level High-High

h. Residual heat removal cubicle sumps 6A & 6B level High-High

i. Pipe tunnel sump 4 level High-High

j. Containment unidentified leakage trouble

k. Containment recirculation cubicle sumps 7A & 7B level High-High

l. Turbine building floor drain sump 1 level High

m. Waste disposal building sumps 9A & 9B level High-High

4. Indicating lights for the following:

   Turbine building floor drain discharge valve directional flow to yard drains or radioactive liquid waste system

5. Indicators for the following:

   a. Incore instrument room sump pump run timer

   b. Containment drains sump pump run timer

   c. Containment drains sump 3 level

   d. Containment unidentified leakage sump pump run timer

   e. Containment unidentified leakage sump 2 level

The turbine plant sampling panel has a control switch with indicating lights for start and stop of the turbine building floor drain sump pump.

<u>Local</u>

1. Control switches with indicating lights (start and stop) for the following pumps:

   a. Auxiliary building sump pump

   b. Residual heat removal cubicle sump pump

c. Turbine building floor drain sump pump

2. Lead-follow selector switch for the following pumps:

   a. Auxiliary building sump pumps

3. Local pressure indicators in the discharge lines of the following pumps:

   Under drain sumps pumps

Radiation monitoring of this system is discussed in Section 11.5

9.3.4 CHEMICAL AND VOLUME CONTROL SYSTEM

9.3.4.1 Design Bases

The Chemical and Volume Control System (CHS), shown on Figure 9.3–7, Figure 9.3–7(1)(A), and Figure 9.3–8, is designed to provide the following services to the reactor coolant system (RCS):

1. Maintenance of programmed water level in the pressurizer, i.e., maintain required water inventory in the RCS.

2. Maintenance of seal-water injection flow to the reactor coolant pumps.

3. Control of reactor coolant water chemistry conditions, activity level, soluble chemical neutron absorber concentration and makeup.

4. Emergency core cooling (part of the system is shared with the emergency core cooling system).

5. Provide means for filling and draining of the RCS.

6. Boration and inventory control for safety grade cold shutdown.

7. Provide reactor coolant purification capabilities during a cold or refueling shutdown

Quantitative design bases are given in Table 9.3–4 with qualitative descriptions given below.

9.3.4.1.1 Reactivity Control

The CHS 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.

<u>Reactor Makeup Control</u>

1. The CHS is capable of borating the RCS through several flow paths and from two boric acid sources.

2. The amount of boric acid stored in the CHS always exceeds that amount required to borate the RCS to cold shutdown concentration. This amount of boric acid also exceeds the amount required to bring the reactor to hot standby and to compensate for subsequent xenon decay.

   In the determination of boration requirements, the initial RCS concentration is based on a minimum expected hot full power or hot zero power condition with peak/maximum xenon. The final RCS cold shutdown concentration accounts for the subsequent xenon decay and assumes that the most reactive control rod is not inserted into the core. This set of conditions requires a minimum usable volume of 28,352 gallons of 6600 ppm borated water from the boric acid tanks (see Table 9.3–4).

   The indicated water volume of the boric acid tanks is equivalent to usable plus unusable water volumes. The unusable volume in each boric acid tank is 1,824 gallons and includes instrument inaccuracy, vortexing, level tap location and suction location. Both boric acid tanks are required to attain the required usable volume due to tank volume limitations. Therefore, the combined total indicated volume requirement is 32,000 (28,352 + 1824 + 1824) gallons from both boric acid tanks.

3. The CHS is capable of borating the RCS to cold shutdown concentration using only safety grade equipment to provide a continuous flow of boric acid solution. (See Section 9.3.4.2.6 for description of safety grade cold shutdown.)

<u>Boron Thermal Regeneration</u>

The CHS is designed to control the changes in reactor coolant boron concentration to compensate for the xenon transients during load follow 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. This system was installed as a design feature of the plant. The present operational practice is not to operate the plant in a load following mode. As a result, the boron thermal regeneration system is installed but not used.

9.3.4.1.2 Regulation of Reactor Coolant Inventory

The CHS 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 (see Chapter 16 for a discussion of maximum allowable RCS leakage). The CHS also functions to provide makeup to the RCS during safety grade cold shutdown operations. See Section 9.3.4.2.6 for a detailed discussion of safety grade cold shutdown.

9.3.4.1.3 Reactor Coolant Purification

The CHS is capable of removing fission and activation products, in ionic 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.

9.3.4.1.4 Chemical Additions for Corrosion Control

The CHS provides a means for adding chemicals to the RCS which 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.

The CHS is capable of maintaining the oxygen content and pH of the reactor coolant within limits specified in Table 5.2.4.

9.3.4.1.5 Seal Water Injection

The CHS is able to continuously supply filtered water to each reactor coolant pump seal, as required by the reactor coolant pump design.

9.3.4.1.6 Hydrostatic Testing of the Reactor Coolant System

A temporary hydrotest pump is provided with the high pressure safety injection system to hydrostatically test the reactor coolant system, when required (Section 6.3).

9.3.4.1.7 Emergency Core Cooling

The centrifugal charging pumps in the CHS also serve as the high-head safety injection pumps in the emergency core cooling system. Other than the centrifugal charging pumps and associated piping and valves, the CHS is not required to function during a loss-of-coolant accident (LOCA), except when the reestablishment of charging/letdown flow is required according to the emergency operation instructions. During a LOCA, the CHS is isolated except for the centrifugal charging pumps and the piping in the safety injection path.

9.3.4.2 System Description

The CHS is shown on Figure 9.3–7, Figure 9.3–7(1)(A), and Figure 9.3–8 with system design parameters listed in Table 9.3–4. The codes and standards to which the individual components of the CHS are designed are listed in Section 3.2. The CHS 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.

9.3.4.2.1 Charging, Letdown, and Seal Water System

The charging and letdown functions of the CHS are employed to maintain a programmed water level in the RCS pressurizer, thus maintaining proper reactor coolant inventory during all phases of plant operation. This is achieved by means of continuous feed and bleed process during which the feed rate is automatically controlled based on pressurizer water level. The bleed rate can be chosen to suit various plant operational requirements by selecting the proper combination of letdown orifices in the letdown flow path.

Should only safety grade equipment be available, makeup and letdown functions could be provided in the cold shutdown design, described in Section 9.3.4.2.6.

Reactor coolant is discharged to the CHS from a reactor coolant loop cold 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 orifice(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, thus preventing flashing downstream of the letdown orifices.

The coolant then flows through the letdown filter to one of the mixed bed demineralizers. The flow may then pass through the cation bed demineralizer which is used intermittently when removal of lithium from the reactor coolant is required for pH control, or to remove cesium.

During reactor coolant boration and dilution operations, especially during load follow, the letdown flow leaving the demineralizers may be directed to the boron thermal regeneration system. The coolant then flows through the reactor coolant filter to the degasifier (radioactive gaseous waste system) and into the volume control tank through a spray nozzle in the top of the tank. Hydrogen from the hydrogen system is continuously supplied to the volume control tank. In the event the degasifier becomes inoperative, fission gases may be stripped from the reactor coolant in the VCT, with the contaminated hydrogen being vented to the radioactive vent system. The partial pressure of hydrogen in the volume control tank determines the concentration of hydrogen dissolved in the reactor coolant for control of oxygen produced by radiolysis of water in the core.

Three centrifugal charging pumps are provided to take suction from the volume control tank and return the cooled, 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 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. The flow is then injected into a cold leg of the RCS. 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 the pressurizer 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 safety grade cold shutdown design described in Section 5.4.7.2.3.5.

A portion of the charging flow is directed to the reactor coolant pumps (nominally 8 gpm per pump) through a seal water injection filter. The flow is directed to 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 while cooling the lower bearing.

The remainder of the flow is directed upward along the pump shaft to the shaft seal. The CVC seal water return (CBO (controlled bleed off)) flows through the pressure breakdown device (PBD) of each stage, discharges to a common manifold, exists 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 passes through the lower, middle and upper stage seal faces. Any residual flow from the seal faces is then discharged to the containment sump.

The excess letdown path is provided as an alternate letdown path from the RCS in the event that the normal letdown path is inoperable. Reactor coolant can be discharged from a RCS crossover leg during initial heating or from the reactor vessel head letdown line during power operation. The loop drain valves are closed with air removed in modes 1-3 to preclude spurious actuation in the post-LOCA containment environment. Discharge flow is directed through the tube side of the excess letdown heat exchanger where it is cooled by component cooling water. Downstream of the heat exchanger, a remote-manual control valve controls the letdown flow. The flow normally joins the 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 containment drains transfer tank or directly into the volume control tank via a spray nozzle. When the normal letdown line is not available, the normal 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.

Surges in RCS inventory due to load changes are accommodated for the most part in the pressurizer. The volume control tank provides 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 controller modulates a three way valve downstream of the reactor coolant filter to divert a portion of the letdown to the boron recovery system via the radioactive gaseous waste system (GWS). 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 recovery system via the GWS.

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 level alarm is actuated. Manual action may correct the situation or, if the level continues to decrease, an emergency low level signal from both level channels causes the suction of the charging pumps to be transferred to the refueling water storage tank.

9.3.4.2.2 Reactor Coolant Purification and Chemistry Control System

Reactor coolant water chemistry specifications are given in Table 5.2–4.

pH Control

The pH control chemical employed is lithium hydroxide. This chemical is chosen for its compatibility 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 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 (Table 5.2–4). If the concentration exceeds this range, as it may during the early stages of a core cycle, the cation bed demineralizer may be 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. As an alternative, an H-OH form resin may be used in the mixed bed demineralizer to remove lithium. If the concentration of Lithium-7 is below the specified limits, lithium hydroxide can be introduced into the RCS via the charging flow. The solution is prepared in the laboratory and poured into the chemical mixing tank. Reactor makeup water is then used to flush the solution to the suction manifold of the charging pumps.

Oxygen Control

During reactor startup from the cold condition, hydrazine is employed as an oxygen scavenging agent. The hydrazine solution is introduced into the RCS in the same manner as described above for the pH control agent. Hydrazine is not employed at any time other than startup from the cold shutdown state.

Dissolved hydrogen is employed to control and scavenge oxygen produced due to radiolysis of water in the core region. Sufficient partial pressure of hydrogen is maintained in the volume control tank such that the specified equilibrium 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 system.

Reactor Coolant Purification

Two mixed bed demineralizers are provided in the letdown line to provide cleanup of the letdown flow. The demineralizers remove ionic corrosion products and certain fission products. One demineralizer is 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 cation bed demineralizer can also be charged with an anion resin mixture for removal of anion impurities or boron. The second mixed bed demineralizer serves as a standby unit for use if the operating demineralizer becomes exhausted during operation, or for removal of lithium if an H-OH form anion resin is used.

A further cleanup feature is provided for use during cold shutdown and residual heat removal. A remote operated valve admits a bypass flow from the residual heat removal system (RHS) into the letdown line upstream of the letdown heat exchanger. The flow passes through the heat exchanger, through a mixed bed demineralizer and the reactor coolant filter to the volume control tank. 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 continuous degasification of the letdown in the radioactive gaseous waste system. The hydrogen is then replaced in the volume control tank.

9.3.4.2.3 Reactor Makeup Control System

The reactor makeup controls consists of a group of instruments, pumps, and valves arranged to provide a manually preset makeup composition to the charging pump suction header or the volume control tank. The makeup control functions are to maintain desired operating fluid inventory in the volume control tank and to adjust reactor coolant boron concentration for reactivity and shim control.

The boric acid is stored in two boric acid tanks. Two boric acid transfer pumps are provided with one pump normally aligned to provide boric acid to the boric acid blender, and the second pump in reserve. On a demand signal by the reactor makeup controller, the pump starts and delivers boric acid to the boric acid blender. The pump can also be used to recirculate the boric acid tank fluid.

During reactor operation, changes are made in the reactor coolant boron concentration for the following conditions:

1. Reactor startup - boron concentration must be decreased from shutdown concentration to achieve criticality.

2. Load follow - boron concentration must be either increased or decreased to compensate for the xenon transient following a change in load.

3. Fuel burnup - boron concentration must be decreased to compensate for fuel burnup and the buildup of fission products in the fuel.

4. Cold shutdown - boron concentration must be increased to the cold shutdown concentration.

The boron thermal regeneration system 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 recovery system.

The control switches for the reactor makeup control system are located on the main control board along with the batch integrators and the flow controllers. Two switches are provided: one for OFF/MANUAL/BORATE/ALTERNATE DILUTE/DILUTE/AUTO MAKEUP and another for STOP/START. The second switch activates the makeup system after the desired mode is selected and the setpoints established. It can also be used to terminate the makeup operation in any of the five modes of operation. The following paragraphs describe the operating modes:

1. Manual

   The manual mode of operation permits the addition of a preselected quantity of boric acid solution at a preselected flow rate to the refueling water storage tank, or through the temporary (flanged) connection to another item of equipment. While in the manual mode of operation, automatic makeup to the reactor coolant system is precluded. The discharge flow path must be aligned by opening manual valves in the desired path.

   The manual mode of operation also permits the addition of dilute boric acid solution at a preselected flow rate to the reactor coolant system to maintain a desired operating fluid level in the volume control tank. The dilute boric acid solution is preset to match the boron concentration in the reactor coolant system. The discharge flowpath must be aligned by manually opening makeup stop valve (FCV-110B).

   The operator sets the mode selector switch to “Manual,” the boric acid and makeup water flow controllers to the desired flow rates, and the boric acid and makeup water batch integrators to the desired quantities and actuates the makeup start switch. Actuating the start switch activates the boric acid flow control valve (FCV-110A) and makeup water flow control valve (FCV-111A) and starts the boric acid transfer pump. When the preset quantities of boric acid and reactor makeup water have been added, the pump stops and boric acid and makeup water flow control valves close. 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 that has been satisfied terminates flow. The flow controlled by the other integrator continues until that integrator is satisfied. The lines are flushed by reactor makeup water, when boric acid is piped through unheated areas of the plant.

2. Borate

The borate mode of operation permits the addition of a preselected quantity of concentrated boric acid solution at a preselected flow rate to the reactor coolant system. The operator sets the mode selector 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 actuates the makeup start. Actuating the start switch opens the makeup stop valve (FCV-110B) to the charging pump suction and the boric acid control valve (FCV-110A) and starts the selected boric acid transfer pump. The concentrated boric acid is added to the charging pump suction header. The total quantity added in most cases is so small that it has only a minor effect on the volume control tank level. When the preset quantity of concentrated boric acid solution has been added, the batch integrator causes the boric acid transfer pump to stop and the concentrated boric acid control valve and the makeup stop valve to close. This operation may be terminated manually at any time by actuating the makeup stop. A deviation in the boric acid flow alarms and terminates the operation after a short time delay.

3. Dilute

The “Dilute” mode of operation permits the addition of a preselected quantity of reactor makeup water at a preselected flow rate to the reactor coolant system. The operator sets the mode selector switch to “Dilute” the reactor makeup water flow controller setpoint to the desired flow rate and the reactor water batch integrator to the desired quantity to actuate the makeup start. The start signal causes the makeup control to open the makeup stop valve (FCV-111B) to the volume control tank inlet and the makeup water flow control valve (FCV-111A). The makeup water is injected through the volume control tank spray nozzle and through the tank to the charging pump suction header. Excessive rise of the volume control tank water level is prevented by automatic actuation of a three-way diversion valve (by the tank level controller), which diverts the reactor coolant letdown flow to the boron recovery system via the radioactive gaseaus waste system. When the preset quantity of reactor makeup water has been added, the batch integrator causes the reactor makeup water control valve to close. This operation may be terminated manually at any time by actuating the makeup stop. A deviation in the reactor makeup water flow alarms and terminates the operation after a time delay.

4. Alternate Dilute

The alternate dilute mode of operation is the same as the dilute mode, except a portion of the dilute water flows directly to the charging pump suction (FCV-110B) and a portion flows into the volume control tank (FCV-111B) via the spray nozzle and then flows to the charging pump suction. This mode of operation minimizes the delay in having to dilute the volume control tank before the RCS can be diluted.

In order to afford precise reactivity control during a dilution to criticality, flow control valve FVC-111B may be shut. This provides a direct path to the RCS for the dilution to criticality and minimizes the mixing delays associated with the use of the VCT.

5. Automatic Makeup

The automatic makeup mode of operation of the reactor makeup control provides dilute boric acid solution, preset to match the boron concentration in the reactor coolant system. The automatic makeup compensates for minor leakage of reactor coolant without causing significant changes in the coolant boron concentration. It operates on demand signals from the volume control tank level controller (LICA-112).

Under normal plant operating conditions, the mode selector switch is set in the “Automatic Makeup” position, and the boric acid and reactor makeup water flow controllers are set to give the same concentration of borated water as contained in the reactor coolant system. The mode selector switch must be in the correct position and the control energized by prior manipulation of the “Start” switch. A low-level signal from the volume control tank level controller (LICA-112) causes the automatic makeup control action to start a boric acid transfer pump and to open the makeup stop valve (FCV-110B), the boric acid flow control valve (FCV-110A), and the reactor makeup water flow control valve (FCV-111A). The flow controllers automatically set the boric acid and reactor makeup water flows to the preset rates.

Makeup addition to the charging pump suction header causes the water level in the volume control tank to rise. At a preset high-level point, the boric acid transfer pump stops, the reactor makeup water and boric acid flow control valves close, and the makeup stop valve closes. This operation may be terminated manually at any time by actuating the makeup stop.

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 for both boric acid and reactor makeup water are provided if flow rates deviate from setpoints. These deviations also close the makeup stop valves (FCV-110B) after a time delay.

6. Makeup Stop

By actuating the makeup stop, the operator can terminate the makeup operation in any of the five modes of operation.

7. Alarm Functions

The reactor makeup control system has alarms to call the operator’s attention to the following conditions:

a. Deviation of total makeup flow rates from control setpoint for more than a short time

b. Deviation of boric acid flow rate from control setpoint for more than a short time

9.3.4.2.4 Boron Thermal Regeneration System

This system was installed as a design feature of the plant. The present operational practice is not to operate the plant in a load following mode. As a result, the boron thermal regeneration system is installed but not used.

Downstream of the mixed bed demineralizers, part of the letdown flow can be diverted to the boron thermal regeneration system where it can be treated when boron concentration changes are desired for load follow. After processing, the flow is returned to a point upstream of the reactor coolant filter.

Storage and release of boron during load follow operation is determined by the temperature of 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 going to the volume control tank.

Therefore, 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 enters the VCT, and is subsequently directed to the RCS via the charging system.

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 volume control tank. The temperature of the letdown stream entering the volume control tank 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 releases boron which was stored by the resin at low temperature during a previous boron storage operation. The boron enriched reactor coolant is returned to the letdown line.

The BTR system is designated as non safety-related and is not designed to Seismic Category 1 requirements.

As an additional function, a thermal regeneration demineralizer can be used as a deborating demineralizer, which would be used to dilute the RCS down to very low boron concentrations towards 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; one resin bed being replaced during each core cycle.

9.3.4.2.5 Component Description

A summary of principal component design parameters is given in Table 9.3–5, and safety classifications and design codes are given in Section 3.2.

All CHS piping that handles radioactive liquid is austenitic stainless steel. All piping joints and connections are welded, except where flanged connections are required to facilitate equipment removal for maintenance and hydrostatic testing.

Charging Pumps

Three centrifugal charging pumps are supplied to inject coolant into the RCS. All parts in contact with the reactor coolant are fabricated of austenitic stainless steel or other material of adequate corrosion resistance. There is a minimum flow recirculation line to protect the centrifugal charging pumps from a closed discharge valve condition. Alternate minimum flow paths are provided when the charging pump is functioning in its engineered safeguards mode. These are described in Section 6.3.

Charging flow rate is controlled through a pressurizer level signal by an automatic flow controller which actuates a modulating valve on the discharge side of the charging pumps. Two charging pumps also serve as safety injection pumps in the emergency core cooling system. A description of the charging pump function upon receipt of a safety injection signal is given in Section 6.3.2.2.

Boric Acid Transfer Pumps

Of the two canned motor pumps supplied, one is normally aligned to supply boric acid to the suction header of the charging pumps while the second serves as a standby. Manual or automatic initiation of the reactor coolant makeup system will start the one pump to provide normal makeup of boric acid solution to the suction header of the charging pumps. Miniflow from this pump flows back to the associated boric acid tank and helps maintain thermal equilibrium. The standby pump may be placed on recirculation to mix the contents of the boric acid tank. Emergency boration, supplying boric acid solution directly to the suction of the charging pumps, can be accomplished by manually starting either or both pumps.

The pumps are located in a heated area to prevent crystallization of the boric acid solution. All parts in contact with the solution are of austenitic stainless steel.

Chiller Pumps

Two centrifugal pumps circulate the water through the chilled water loop in the boron thermal regeneration system. One pump is normally operated, with the second serving as standby.

Regenerative Heat Exchanger

The regenerative heat exchanger is designed to recover heat from the letdown flow by reheating the charging flow, which reduces thermal effects on the charging penetrations into the reactor coolant loop piping.

The letdown stream flows through the shell of the regenerative heat exchanger and 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 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 of the letdown flow upstream of the heat exchanger in a range sufficiently high to prevent two phase flow. 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. A temperature sensor, which is part of the CVCS, provides input to the controller in the component cooling system. The exit temperature of the letdown stream is thus 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 valve diverts the letdown directly to the volume control tank, bypassing the CVCS demineralizers, to protect the resin beds.

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. This flowrate 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 when normal letdown is inoperable to maintain the reactor in operation. The excess letdown flows through the tube side of the unit and component cooling water is circulated through the shell side. 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. Equivalent instrumentation is also provided upstream of the heat exchanger in the header from the reactor vessel head letdown line.

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; it is used in setting the control valve to ensure that this pressure does not exceed the allowable backpressure on the RCP seals.

Seal Water Heat Exchanger

The seal water heat exchanger is designed to cool fluid from three sources: reactor coolant pump CVC seal return (CBO), reactor coolant discharged from the excess letdown heat exchanger, and a miniflow from a centrifugal charging pump. 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 centrifugal charging pump. The unit is designed to cool the above flow to the temperature normally maintained in the volume control tank. 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 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 cool the liquid leaving the thermal regeneration demineralizers to ensure that its temperature does not exceed that of normal letdown to the volume control tank.

Letdown Reheat Heat Exchanger

The letdown reheat heat exchanger is used only during boron release operations and it is then used 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 volume control tank (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 to the boron recovery system via the GWS. The tank also provides the means for introducing hydrogen into 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 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 hydrogen system is continuously supplied to the volume control tank while a remotely operated vent valve, discharging to the radioactive gaseous waste system permits an alternate means of removal of gaseous fission products. These are stripped from the reactor coolant and collected in VCT in the event that the degasifier becomes inoperative. 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.

Volume control tank pressure is monitored with indication given in the control room. Alarm is actuated in the control room for high and low pressure conditions. The volume control tank pressure is controlled by the VCT vent header isolation valve and VCT vent valve.

Two level channels govern the water inventory in the volume control tank. Level indication with a high and low alarm is provided on the main control board for one controller and local level indication with a high and low alarm on the main control board is provided for the other controller.

If the volume control tank level rises above the normal operating range, one level channel provides an analog signal to the controller which modulates the three-way valve downstream of the reactor coolant degasifier (in the GWS) to maintain the volume control tank level within the normal operating band. The three-way valve can split letdown flow so that a portion goes to the boron recovery system via the GWS and a portion to the volume control tank. The controller would operate in this fashion during the dilution operation when reactor makeup water is being fed to the volume control tank from the reactor makeup control system.

If the modulating function of the channel fails and the volume control tank level continues to rise, the high level alarm alerts the operator to the malfunction and the full letdown flow is automatically diverted by the backup level channel.

During normal power operation, a low level in the volume control tank initiates auto makeup which injects a pre-selected 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, auto 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 both level channels opens the stop valves in the supply line from RWST to charging pump suction, and closes the stop valves in the volume control tank outlet line, and actuates an alarm.

Boric Acid Tanks

The boric acid storage system has the capacity to store sufficient boric acid solution for refueling, or enough for a cold shutdown from full power operation with the most reactive control rod not inserted.

The concentration of boric acid solution in storage is maintained between 6600 and 7175 ppm. The contents of the boric acid tanks are sampled after filling, but prior to placing them in service. Therefore, measured amounts of boric acid solution can be delivered to the reactor coolant to control the boron concentration.

A temperature sensor provides temperature measurement of each tank's contents. Temperature indication, as well as high and low temperature alarms, are provided in the main control board.

Two level detectors indicate the level in each boric acid tank. Level indication with a high, low, and empty level alarm is provided on the main control board. The high alarm indicates that the tank may soon overflow. The low alarm warns the operator to start makeup to the tank. 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 preparation of caustic solutions for pH control and hydrazine solution for oxygen scavenging.

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 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 or an H-HO form resin are charged into the demineralizers. The anion resin is converted to the borate form in operation. Both types of resin remove fission and corrosion products. In particular, the H-OH form resin will remove lithium. The resin bed is designed to reduce the concentration of ionic isotopes in the purification stream, except for cesium, tritium, and molybdenum, by a minimum factor of 10.

Each demineralizer has more than sufficient capacity for one core cycle with one 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 and if the letdown temperature exceeds the maximum allowable resin operating temperature (approximately 140°F), a three-way valve is automatically actuated to bypass the flow around 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 volume control tank.

Cation Bed Demineralizer

A flushable demineralizer with cation resin in the hydrogen form or anion resin in the hydroxyl form is located downstream of the mixed bed demineralizer and is used intermittently to control the concentration of Li^7 which builds up in the coolant from the B^{10} (n, α) Li^7 reaction. The demineralizer also has sufficient capacity to maintain the Cesium-137 concentration in the coolant below 5.0 μCi/cc with 0.29 percent defective fuel. The resin bed is designed to reduce the concentration of ionic isotopes, particularly cesium, and molybdenum by a minimum factor of 10.

The demineralizer has more than sufficient capacity for one core cycle with one percent of the rated core thermal power being generated by defective fuel rods. If desired, the cation resin may be replaced with an anion resin for removal of boron or anion impurities.

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 in 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 much 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 setpoint, an alarm is sounded on the main control board and the letdown flow is diverted to the volume control tank 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 concentrations and increased margin for shutdown. If the temperature of the resin rises significantly above 140°F, the number of ion storage sites 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 occurs 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 reactor coolant boron concentration is limited by the capacity of the resin to remove boron from the water (Chapter 15). As the boron concentration is reduced, the control rods would be driven into the core to maintain power level. If the rods were to reach the shutdown limit setpoint, an alarm would be actuated informing the operator that emergency boration of the RCS is necessary in order to maintain capability of shutting the reactor down with control rods alone.

Reactor Coolant Filter

The reactor coolant filter is located in the letdown line upstream of the degasifier. The filter collects resin fines and particulates from the letdown stream. The nominal flow capacity of the filter is greater than the maximum purification flow rate.

Two local pressure indicators are provided to show the pressures upstream and downstream of the reactor coolant filter and thus provide filter differential pressure.

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.

Seal Water Return Filter

The 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.

Two local pressure indicators are provided to show the pressure upstream and downstream of the filter and thus provides differential pressure across the filter.

Letdown Filter

The letdown filter is placed in the letdown line to prevent particulate from collecting in the mixed bed demineralizers. This arrangement is intended to increase resin life. The filter is sized to accommodate maximum purification flow rate. It is provided with vent and drain connections. Upstream and downstream line pressures are indicated locally, providing differential indication.

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.

Local pressure indicators indicate the pressure upstream and downstream of the boric acid filter and thus provide filter differential pressure.

Letdown Orifices

Three letdown orifices are provided to reduce the letdown pressure from reactor conditions and to control the flow of reactor coolant leaving the RCS. The orifices are placed into or out of service by remote operation of their respective isolation valves. One orifice is designed for normal letdown flow with the other two serving as standby. One or both of the standby orifices may be used in parallel with the normally operating orifice for either flow control when the RCS pressure is less than normal or greater letdown flow during maximum purification or heatup. Letdown flow is administratively controlled to approximately 120 gpm or less by selection of orifices. Each orifice 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 a high alarm to indicate unusually high flow.

A low pressure letdown control valve, 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 two fold:

1. To cooldown the process stream during storage of boron on the resin.

2. To maintain an outlet temperature from the boron thermal regeneration system at or below 115°F during release of boron.

Valves

Where pressure and temperature conditions permit, diaphragm type valves are used to essentially eliminate leakage to the atmosphere. All packed valves which are larger than two inches and which are designated for radioactive services are provided with a stuffing box and lantern leakoff connections. All control (modulating) and three-way valves are either 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.

Relief valves are provided for lines and components that might be pressurized above design pressure by improper operation or component malfunction.

1. Charging Line Downstream of Regenerative Heat Exchanger

   If the charging side of the regenerative heat exchanger is isolated while the hot letdown flow continues at its maximum rate, the volumetric expansion of coolant on the charging side of the heat exchanger is relieved to the RCS through a spring loaded check valve.

2. Letdown Line Downstream of Letdown Orifices

   The pressure relief valve downstream of the letdown orifices protects the low pressure piping and the letdown heat exchanger from overpressure when the low pressure piping is isolated. The capacity of the relief valve is equal to the maximum flow rate through all letdown orifices. The valve set pressure is equal to the design pressure of the letdown heat exchanger tube side.

3. Letdown Line Downstream of Low Pressure Letdown Valve

   The pressure relief downstream of the low pressure letdown valve protects the low pressure piping and equipment from overpressure when this section of the system is isolated. The overpressure may result from leakage through the low pressure letdown valve. The capacity of the relief valve exceeds the maximum flow rate through all letdown orifices. The valve set pressure is equal to the design pressure of the demineralizers. The valve discharges to a common relief header (shared with the Seal Water Return Line [Charging Pumps Bypass Flow] and Letdown Reheat Heat Exchanger) to the Volume Control Tank. The common relief header has been designed and analyzed to demonstrate that adequate system relief capacity is provided in accordance with NC-7512.

4. Volume Control Tank

The relief valve on the volume control tank permits the tank to be designed for a lower pressure than the upstream equipment. This valve has a capacity greater than the summation of the following items: maximum letdown, normal seal water return, excess letdown and nominal flow from one reactor makeup water pump. The valve set pressure equals the design pressure of the volume control tank.

5. Charging Pump Suction

A relief valve on the charging pump suction header and a relief valve on each charging pump suction line relieve pressure that may build up if the suction line isolation valves are closed or if the system is over pressurized. The valves set pressure is equal to the design pressure of the associated piping and equipment.

6. Seal Water Return Line (Inside Containment)

This relief valve is designed to relieve overpressurization in the seal water return piping inside the containment if the motor-operated isolation valve is closed. The valve is designed to relieve the total CVC seal return (CBO) flow from the seal of the reactor coolant pumps plus the design excess letdown flow. The valve is set to relieve at the design pressure of the piping.

7. Seal Water Return Line (Charging Pumps Bypass Flow)

This relief valve protects the seal water heat exchanger and its associated piping from overpressurization. If either of the isolation valves for the heat exchanger are closed and if the bypass line is closed, the piping would be over pressurized by the miniflow from the centrifugal charging pumps. The valve is sized to handle the miniflow from the centrifugal charging pumps. The valve is set to relieve at the design pressure of the heat exchanger. The valve discharges to a common relief header (shared with the Letdown Line Downstream of the Low Pressure Letdown Valve and the Letdown Re-heat Heat Exchanger) to the Volume Control Tank. The common relief header has been designed and analyzed to demonstrate that adequate system relief capacity is provided in accordance with NC-7512.

8. Letdown Reheat Heat Exchanger

The relief valve is located on the piping leading from the shell side of the heat exchanger. If the shell side were isolated while flow was maintained in the tube side, overpressurization could occur. The valve is set to relieve at the design pressure of the heat exchanger shell side. The valve discharges to a common relief header (shared with the Seal Water Return Line [Charging Pumps Bypass Flow] and the Letdown Line Downstream of the Low Pressure Letdown Valve) to the Volume Control Tank. The common relief header has been designed and analyzed to demonstrate that adequate system relief capacity is provided in accordance with NC-7512.

9. Letdown Chiller Heat Exchanger

   The relief valve is located on the piping leading from the shell side of the heat exchanger. If the shell side were isolated while flow was maintained in the tube side, overpressurization could occur. The valve is set to relieve at the design pressure of the heat exchanger shell side.

10. Steam Line to Batching Tank

    The relief valve on the steam line to the batching tank protects the low pressure piping and batching tank heating jacket from overpressure when the condensate return line is isolated. The capacity of the relief valve equals the maximum expected steam inlet flow. The set pressure equals the design pressure of the heating jacket.

11. Charging Pump Discharge

    The alternate miniflow upstream isolation valves (8511A, 8511B) are normally closed, isolating the alternate miniflow lines from the charging pumps discharge. On an SIS signal, these isolation valves open, allowing the discharge of the pumps to be protected from overpressurization when the normal miniflow recirculation lines are isolated. The alternate minimum flow lines discharge to the RWST.

Piping

All CHS piping that handles radioactive liquid is austenitic stainless steel. All piping joints and connections are welded, except where flanged connections are required to facilitate equipment removal for maintenance and hydrostatic testing.

9.3.4.2.6 System Operation

Plant Startup

Plant startup is defined as the operations which bring the plant from cold shutdown to normal operation temperature and pressure.

It is assumed that:

1. Normal residual heat removal is in progress.

2. RCS boron concentration is at the cold shutdown concentration.

3. Reactor makeup control system is set to provide makeup at the cold shutdown concentration.

4. RCS is either water solid or drained to minimum level for the purpose of refueling or maintenance. If the RCS is water solid, system pressure is maintained by operation of a charging pump and controlled by the low pressure letdown valve in the letdown line (letdown is achieved via the residual heat removal system).

5. The charging and letdown lines of the CHS are filled with coolant at the cold shutdown boron concentration. The letdown orifice isolation valves are closed.

If the RCS requires filling and venting, the procedure is as follows:

1. One charging pump is started, which provides blended flow from the reactor makeup control system at the cold shutdown boron concentration.

2. The vents on the head of the reactor vessel and pressurizer are opened.

3. The RCS is filled and the vents closed.

Overpressure protection is provided by the relief valves in the RHR system. The letdown orifice isolation valves, which are normally open during cold shutdown, provide additional overpressure protection.

The system pressure is raised by using the charging pump and controlled by the low pressure letdown valve. When the system pressure is adequate for operation of the reactor coolant pumps, seal water flow to the pumps is established and the pumps are operated and vented sequentially until all gases are cleared from the system. Final venting takes place at the pressurizer.

When it is desired to form a pressurizer bubble, after the filling and venting operations are completed, charging and low pressure letdown flows are established. The pressurizer heaters are then energized. Steam bubble formation in the pressurizer is accomplished by increasing the letdown flow above the charging flow. When the pressurizer water level reaches the no-load programmed setpoint, the pressurizer level control is shifted to control the charging flow to maintain programmed level. The RHS is then isolated from the RCS and the normal letdown path is established. The pressurizer heaters are now used to increase the RCS pressure.

The reactor coolant boron concentration is now reduced either by operating the reactor makeup control system in the “Dilute” mode or by operating the boron thermal regeneration system in the boron storage mode, and when the resin beds are saturated, washing off the beds to the boron recovery system. The reactor coolant boron concentration is reduced to the point where criticality is achieved. Criticality is achieved by control rod withdrawal and not by boron dilution except for initial criticality following refueling. Nuclear heatup may then proceed with corresponding manual adjustment of the reactor coolant boron concentration to balance the temperature coefficient effects and maintain the control rods within their operating range. During heatup, the appropriate combination of letdown orifices is used to provide necessary letdown flow.

Prior to or during the heating process, the CHS is employed to obtain the correct chemical properties in the RCS. Chemicals are added through the chemical mixing tank as required to control reactor coolant chemistry, such as pH and dissolved oxygen content. Hydrogen overpressure is established in the volume control tank to assure the appropriate hydrogen concentration in the reactor coolant.

Power Generation and Hot Standby Operation

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 pump and the normal purification of the RCS. One charging pump is employed and charging flow is controlled automatically from pressurizer level. The only adjustments in boron concentration necessary are those to compensate for core burnup. These adjustments are made at infrequent intervals to maintain the control groups within their allowable limits. Rapid variations in power demand are accommodated automatically by control rod movement when in automatic rod control. 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 maintain the control groups within their maneuvering band.

During normal operation, normal letdown flow is maintained and one mixed bed demineralizer is in service. Reactor coolant samples are taken periodically to check boron concentration, water quality, pH and activity level. The charging flow to the RCS is controlled automatically by the pressurizer level control signal through the discharge header flow control valve.

Load Follow

A power reduction will initially cause a xenon buildup followed by xenon decay to a new, lower equilibrium value. The reverse occurs if the power level increases; initially, the xenon level decreases then it increases to a new and higher equilibrium value associated with the amount of the power level change.

The boron thermal regeneration system is normally used to vary the reactor coolant boron concentration to compensate for xenon transients occurring when reactor power level is changed. The reactor makeup control system may also be used to vary the boron concentration in the reactor coolant.

The most important intelligence available to the plant operator, enabling him to determine whether dilution or boration of the RCS is necessary, is the position of the control rods. For example, if the control rods are below their desired position, the operator must borate the reactor coolant to bring the rods outward. If, on the other hand, the control rods are above their desired position, the operator must dilute the reactor coolant to bring the rods inward.

During periods of plant loading, the reactor coolant expands as its temperature rises. The pressurizer absorbs this expansion as the level controller raises the level setpoint to the increased level associated with the new power level. The excess coolant due to RCS expansion is letdown and stored in the volume control tank. During this period, the flow through the letdown orifice remains constant and the charging flow is reduced by the pressurizer level control signal, resulting in an increased temperature at the regenerative heat exchanger outlet. The temperature controller downstream from the letdown heat exchanger increases the component cooling water flow to maintain the desired letdown temperature.

During periods of plant unloading, the charging flow is increased to make up for the coolant contraction not accommodated by the programmed reduction in pressurizer level.

Hot Standby

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 control rods. During this hot standby period, temperature is maintained at no-load T by initially dumping steam to remove core residual heat, or at later stages, by running reactor coolant pumps to maintain system temperature.

Following shutdown, xenon buildup occurs and increases the degree of shutdown margin. Immediately following shutdown from equilibrium full power operation, the core is maintained subcritical to the shutdown margin required by the Technical Specifications by the equilibrium xenon present in the fuel and by the insertion of the control rods (with the exception of the most reactive control rod). The effect of xenon buildup is to increase the shutdown margin by approximately 1.5 to 2 percent Δ k/k at about 8 hours following shutdown from equilibrium full power conditions. If hot standby is maintained past this point, xenon decay results in a decrease in the degree of shutdown margin to the initial equilibrium value at about 20 to 25 hours after shutdown from equilibrium full power conditions. For periods beyond 20 to 25 hours after shutdown from equilibrium full power conditions, subsequent decay of xenon may result in a reduction of shutdown margin below the value required in the Technical Specifications, and may cause an eventual return to criticality unless boration is used to counteract the xenon decay and maintain the minimum shutdown margin.

If a rapid recovery is required, dilution of the system may be performed to counteract this xenon buildup. However, after the xenon concentration reaches a peak, boration must be performed to maintain the reactor subcritical as the xenon decays out.

Plant Shutdown

Plant shutdown is the operation which takes the plant from hot standby to cold shutdown conditions. The reactor is subcritical by 3 percent Δ k/k or greater (depending on critical boron concentration), and $T_{avg} \leq 200°F$.

Normal Cold Shutdown

Before initiating a cold shutdown, the RCS hydrogen concentration is lowered by reducing the VCT overpressure, by replacing the VCT hydrogen atmosphere with nitrogen, and by continuous purging to the GWS.

Before cooldown and depressurization of the plant is initiated, the reactor coolant boron concentration is increased to the cold shutdown value. After the boration is completed and reactor coolant samples verify that the concentration is correct, the operator resets the RMCS for leakage and sets the system concentration 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 VCT level. The VCT level controller automatically initiates makeup to maintain the inventory. Depressurization is performed by cooling the vapor space of the pressurizer with spray flow from an RCS loop with an operating RCP.

After the RHRS is placed in service and the RCPs are shut down, further cooling of the pressurizer liquid is accomplished by charging through the auxiliary spray line from the outlet of the CHS regenerative heat exchanger. Coincident with plant cooldown, a portion of the reactor coolant flow is diverted from the RHS to the CHS for cleanup. Demineralization of ionic radioactive impurities and stripping of fission gases reduce the reactor coolant activity level sufficiently to permit personnel access for refueling or maintenance operations.

Safety Grade Cold Shutdown

It is expected that the CHS would perform normally during shutdown under safety grade conditions. Special design features are employed to ensure that the CHS functions relied upon for cold shutdown are always available. Should other portions of the CHS not be operable, the operator would follow contingent procedures to use the safety grade backup systems of the cold shutdown design (described in Section 5.4.7).

During the first phase of safety grade cold shutdown, the CHS is used to borate the RCS to the required cold shutdown margin while the plant is maintained at hot standby (i.e., the RCS is borated prior to cooldown). Borated water is injected from the boric acid tanks to the suction of the charging pumps via the safety-grade gravity drain lines. Control of the boration rate is accomplished with one of two CHS throttling valves (CHS*HCV190A or CHS*HCV190B). Each valve is powered by a separate power train to ensure the boration control function can be performed with a single failure. Valve CHS*HCV190A can be used to control boration rate through the charging bypass line while CHS*HCV190B can be used to control boration rate through the ECCS high head safety injection lines. To ensure integrity of the reactor coolant pump seal, reactor coolant pump seal cooling is also maintained.

Since boration to the cold shutdown margin is accomplished prior to cooldown, no credit can be taken for coolant shrinkage. In order to maintain the RCS inventory constant during the boration phase, the mass flow rate injected by charging must equal the mass flow rate removed by letdown. Since it is assumed that the CHS letdown line is not available under safety grade conditions, the addition to the RCS inventory is accommodated by letdown using the reactor vessel head vent system. Safety-grade letdown flow via the reactor vessel head vent system terminates at the pressurizer relief tank.

As the RCS cools, additional borated water must be injected from either the boric acid tanks or the refueling water storage tank to make up for coolant shrinkage; however, no letdown is required. Near the end of this phase of cooldown, the RCS is depressurized by cooling the pressurizer. Since it is assumed that neither the RCPS nor the CHS auxiliary spray path are available under safety grade conditions, this function is performed by the safety-grade pressurizer power-operated relief valves.

A more detailed description of safety grade cold shutdown is provided in Section 5.4.7.

9.3.4.3 Safety Evaluation

The classification of structures, components, and systems is presented in Section 3.2. A further discussion on seismic design categories is given in Section 3.7. Conformance with NRC General Criteria for the plant systems, components, and structures important to safety is presented in Section 3.1. Also, Section 1.8 provides a discussion on applicable Regulatory Guides.

9.3.4.3.1 Reactivity and Inventory Control

Normal Plant Operation and Safe Shutdown

The CHS is used to control the soluble neutron absorber and maintain proper inventory in the RCS. Redundant pumps, valves, flow paths, and sources of boron are provided to optimize this performance under normal conditions.

Any time the plant is at power, the quantity of boric acid retained in the boric acid tanks and ready for injection always exceeds 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 standby and to compensate for subsequent xenon decay. An adequate quantity of boric acid is also available in the refueling water storage tank to achieve cold shutdown.

Redundant paths are provided between the boric acid tanks and the two boric acid transfer pumps, either of which can supply boric acid to the suction of any of the three centrifugal charging pumps. As a backup to the normal boric acid supply, the operator can align the RWST outlet to the suction of the charging pumps.

Two separate and independent flow paths are available for supplying borated water to the RCS. Should the normal charging line be unavailable, charging to the RCS would be continued via RCP seal injection.

Certain initiating HELB events, postulated to occur in the operating CHS pump discharge piping, when combined with a single active failure of the standby CHS pump to start, may lead to a loss of all charging. In addition, all charging may be lost as a result of certain postulated fire conditions (See FSAR Section 9.5.1 and the FPER for SIH system performance requirements). For these conditions, the SIH pumps will provide the required RCS inventory and boration flow to achieve safe shutdown.

When the reactor is subcritical (i.e., during hot standby cold shutdown, refueling and approach to criticality), the neutron source multiplication is continuously monitored and indicated. Any appreciable increase in the neutron source multiplication, including that caused by the maximum physical boron dilution rate, would be slow enough to give ample time to start a corrective action to prevent the core from becoming critical. (The boron dilution accident is discussed in Section 15.4.)

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 120 minutes. In less than 120 additional minutes, enough boric acid can be injected to compensate for xenon decay, although xenon decay below the equilibrium operating level does 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.

Reactor coolant pump seal injection can be used to supply borated water to the RCS at a rate of approximately 5 gal/min per pump. Using boric acid solution at the charging rate of 20 gal/min (5 gal/min per RCP), approximately 6 hours are required to add enough 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.

The CVCS is capable of making up for a small RCS fluid leak of approximately 130 gpm using one centrifugal pump and still maintaining seal injection flow to the RCPs. The maximum break size for which the normal makeup system can maintain the pressurizer level is obtained by comparing the calculated flow from the RCS through the postulated break against the charging pump makeup flow at normal RCS pressure (2,250 psia). A makeup flow rate from one charging pump is adequate to sustain pressurizer pressure at 2,250 psia for a break through a 0.375 inch diameter hole. This break results in a loss of approximately 17.5 lb/sec. This also allows for minimum RCS cooldown contraction and is accomplished with the letdown isolated.

Safety Grade Cold Shutdown Operations

Portions of the CHS are also relied upon to perform in conjunction with other systems in the cold shutdown design to control the reactivity and inventory of the RCS.

The amount of boric acid stored in the two boric acid tanks always exceeds the amount required to borate the RCS to cold shutdown concentration, assuming that the control assembly with the highest reactivity worth is stuck in its fully withdrawn position.

Gravity drain lines are provided from the boric acid tanks to the charging pump suction header. For makeup for primary shrinkage due to RCS cooldown, borated water from the RWST can be provided to any of the three charging pumps via the suction lines provided for safety injection.

Should the normal charging path not be available for boration or makeup, redundant safety grade paths with necessary throttling capability are provided by the charging bypass flowpath and ECCS high head safety injection headers. Under safety grade conditions, the CHS is capable of borating the RCS to a cold shutdown concentration at a rate that is compatible with the objectives of the cold shutdown design, described in Section 5.4.7.2.3.5 (Safety grade letdown to accommodate boration is also discussed in Section 5.4.15.2.)

Certain initiating HELB events, postulated to occur in the operating CHS pump discharge piping, when combined with a single active failure of the standby CHS pump to start, may lead to a loss of all charging. In addition, all charging may be lost as a result of certain postulated fire conditions (See FSAR Section 9.5.1 and the FPER for SIH system performance requirements). For these conditions, the SIH pumps will provide the required RCS inventory and boration flow to achieve safe shutdown.

Since inoperability of a single component does not impair ability to meet boration and makeup requirements, plant operating procedures allow components to be temporarily out of service for repairs. However, with an inoperable component, the ability to tolerate additional component failure is limited. Therefore, when the RCS is in Modes 1, 2, or 3, operating procedures require immediate action to effect repairs of an inoperable component, restrict permissible repair time, and demonstrate the operability of the redundant component. Also available are appropriate operating procedures for the use of the CHS in conjunction with other systems in the cold shutdown design.

9.3.4.3.2 Reactor Coolant Purification

The CHS is capable of reducing the concentration of ionic isotopes in the purification stream as required in the design basis. This is accomplished by passing the letdown flow through one of the mixed bed demineralizers which removes ionic isotopes, except those of cesium, molybdenum, and yttrium, with a minimum decontamination factor of 10. Through occasional use of the cation bed demineralizer, the concentration of cesium can be maintained below 1.0 μci/cc, assuming one percent of the rated core thermal power is being produced by fuel with defective cladding. The cation bed demineralizer is capable of passing the maximum purification letdown flow, though only a portion of this capacity is normally utilized. Each mixed bed demineralizer is capable of processing the maximum purification letdown flow rate. If the normally operating mixed bed demineralizer's resin has become exhausted, the second demineralizer can be placed in service. Each demineralizer is designed, however, to operate for one core cycle with one percent defective fuel.

A further cleanup feature is provided for use during residual heat removal operations. A remote-operated valve admits a bypass flow from the RHS into the letdown line at a point upstream of the letdown heat exchanger. The flow passes through the heat exchanger and then passes through one of the mixed bed demineralizers and the reactor coolant filter to the volume control tank. The fluid is then returned to the RCS via the normal charging route.

The maximum temperature that will be allowed for the mixed bed and cation bed demineralizers is approximately 140°F. If the temperature of the letdown stream approaches this level, the flow will be automatically diverted so as to bypass the demineralizers. If the letdown is not diverted, the only consequence would be a decrease in ion removal capability. Ion removal capability starts to decrease when the temperature of the resin goes above approximately 140°F. The resins do not lose their exchange capability immediately. Ion exchange still takes place (at a faster rate) when temperature is increased. However, with increasing temperature, the resin loses some of its ion exchange sites along with the ions that are held at the lost sites. The ions lost from the sites may be reexchanged farther down the bed. The number of sites lost is a function of the temperature reached in the bed and of the time the bed remains at the high temperature. Some capability for ion exchange is retained as long as there are some ion exchange sites available.

There would be no safety problem associated with overheating of the demineralizer resins. The only effect on reactor operating conditions would be the possibility of an increase in the reactor coolant activity level. If the activity level in the reactor coolant were to exceed the limit given in the Technical Specifications, reactor operation would be restricted as required by the Technical Specifications.

9.3.4.3.3 Seal Water Injection

Flow to the reactor coolant pump seals can be provided by three charging pumps, any one of which is capable of supplying the normal charging line flow plus the nominal seal water flow.

9.3.4.3.4 Hydrostatic Testing of the Reactor Coolant System

Hydrotesting is achieved through the use of a hydrotest pump in the high-pressure safety injection system (Section 6.3).

9.3.4.3.5 Leakage Provisions

CHS components, valves, and piping which see radioactive service are designed to limit leakage to the atmosphere. The following are preventive means which are provided to limit radioactive leakage to the environment.

1. Where pressure and temperature conditions permit, diaphragm type valves are used to essentially eliminate leakage to the atmosphere.

2. All packed valves which are larger than 2 inches and which are designated for radioactive service are provided with a stuffing box and leakoff connections.

3. All control (modulating) and three-way valves are either provided with stuffing box and leakoff connections or are totally enclosed.

4. Welding of all piping joints and connections, except where flanged connections are provided to facilitate maintenance and hydrostatic testing.

The volume control tank provides an inferential measurement of leakage from the CHS as well as the RCS. The amount of leakage can be inferred from the amount of makeup added by the reactor makeup control system.

During normal operation, the hydrogen and fission gases in the letdown stream (degasifier) are continuously purged to the radioactive gaseous waste system to limit the release of radioactive gases through leakage by maintaining the radioactive gas level in the reactor coolant several times lower than the equilibrium level. Also provided are two mixed bed demineralizers which maintain reactor coolant purity, thus reducing the radioactivity level of the RCS water.

9.3.4.3.6 Ability to Meet the Safeguards Function

A failure analysis of the portion of the CHS which is safety related (used as part of the emergency core cooling system) is included as part of the emergency core cooling system failure analysis presented in Tables 6.3.5 and 6.3.6.

9.3.4.3.7 Heat Tracing

Heat tracing requirements for boric acid solutions depend mainly on the solution concentration. For this plant, the concentration of boric acid ranges from 10 ppm to 7175 ppm. Electrical heat tracing is not required on any CHS component which contains 7175 ppm (4.1 weight percent) boric acid, providing these components are located in a room maintained at 59°F or higher. Temperature alarms, one for the boric acid tank room and one for the boric acid storage tank, are provided to assure room temperature does not go below 67°F.

9.3.4.3.8 Abnormal Operation

The CHS is capable of making up for a small RCS leak of approximately 130 gpm using one 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.

9.3.4.3.9 Failure Mode and Effects Analysis

Portions of the CHS are relied upon for safe shutdown and accident mitigation. The failure mode and effects analysis (FMEA), summarized in Table 9.3–6, demonstrates that single component failures do not compromise the CHS safe shutdown functions of boration and makeup. The FMEA also shows that single failures occurring during CHS operation do not compromise the ability to prevent or mitigate accidents. These capabilities are accomplished by a combination of suitable redundance, instrumentation for indication and/or alarm abnormal conditions, and relief valves to protect piping and components against malfunctions.

Portions of the CHS are also relied upon to provide safety grade boration and makeup. The capability of the CHS to perform in conjunction with other systems of the cold shutdown design is presented in the Section 5.4.7.

9.3.4.4 Testing Requirements and Inspection

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.

Technical Specifications (Chapter 16) have been established concerning calibration, checking, and sampling of the CHS.

Refer to Chapter 14 for further information pertaining to preoperational testing.

9.3.4.5 Instrumentation Requirements

Process control instrumentation is provided to acquire data concerning key parameters about the CHS. The location of the instrumentation is shown on Figure 9.3–7, Figure 9.3–7(1)(A), and Figure 9.3–8.

The instrumentation furnishes input signals for monitoring and/or alarming purposes. Indication and/or alarms are provided for the following parameters:

1. Temperature
2. Pressure
3. Flow
4. Water level

The instrumentation also supplies input signals for control purposes. Some specific control functions are:

1. Letdown flow is diverted to the volume control tank upon high temperature indication upstream of the mixed bed demineralizers.
2. Pressure upstream of the letdown heat exchanger is controlled to prevent flashing of the letdown liquid.
3. Charging flow rate is controlled during charging pump operation.

4. Volume control tank water level is controlled.

5. Temperature of the boric acid solution in the batching tank is maintained.

6. Reactor makeup is controlled.

7. Temperature of letdown flow to the boron thermal regeneration system is controlled.

8. Temperature of the chilled water flow to the letdown chiller heat exchanger is controlled.

9. Temperature of letdown flow return from the boron thermal regeneration demineralizers is controlled.

9.3.5 BORON RECOVERY SYSTEM

The boron recovery system is capable of processing reactor coolant to recover primary grade water and boric acid for reuse or disposal (Figure 9.3–9). The liquid entering the boron recovery system is produced by the feed and bleed operations necessary to maintain the boron concentration in the reactor coolant at the desired level. This liquid is reactor coolant letdown from the chemical and volume control system (CHS) (Section 9.3.4) through the radioactive gaseous waste system (GWS) (Section 11.3). The liquid has been processed through a mixed bed demineralizer and degasifier.

9.3.5.1 Design Bases

The design bases for the boron recovery system are:

1. The system will process the letdown liquid generated by normal unit operations, under either base loaded or load following conditions.

2. The system will handle, by means of sufficient tankage, one cold shutdown-startup sequence at any time prior to the fuel cycle being approximately 95 percent complete with no boron evaporator availability.

3. The system will handle a back-to-back cold shutdown-startup sequence until the time the reactor is first control limited in its ability to follow the programmed weekly load schedule with limited boron evaporator availability (65 hours during back-to-back sequence).

4. The system will accommodate a programmed weekly unit load schedule consisting of 52 hours at a weekend power level of 30 percent power, followed by an increase to full power in 4 hours, and then 4 days of power operation - each day consisting of 12 hours at full power, a decrease to 50 percent power in 3 hours, remaining there for 6 hours, and then returning to full power in 3 hours. The 4 days are

followed by 12 hours of full power operation, followed by a return in 4 hours to the weekend power level of 30 percent power.

5. The system will have an evaporator availability of 90 percent for any 30-day period during normal operation.

6. The system is capable of producing distillate from the boron evaporator with approximately 5 ppm boron and to include provision by means of the boron demineralizers (mixed bed ion exchange units) to reduce the boron concentration even further below 5 ppm if desired.

7. The system is capable of producing an effluent from the boron recovery system to the radioactive liquid waste system (LWS) discharge with an activity, excluding tritium, of less than the values given in the LWS (Section 11.2). This liquid is discharged as required to maintain a water balance within the unit and to control the tritium concentration in the reactor coolant. Tables 11.2-11 and 11.2-14 list the expected and design radionuclide concentrations in the effluent from the boron recovery system.

8. The system will produce, from the boron evaporator bottoms, boric acid solutions of either 4 percent by weight for reuse in the reactor plant, or 12 percent by weight boric acid for processing in the radioactive solid waste system (WSS). The radionuclide concentration in the boron evaporator bottoms for the maximum expected case is discussed in Chapter 11.

9. This system is not safety related, and is designated nonnuclear safety (NNS) and nonseismic.

9.3.5.2 System Description

The boron recovery system is shown on Figure 9.3–9. Characteristics of the components of the boron recovery system are shown in Table 9.3–7.

The plant operates primarily as a base loaded unit. It was originally designed to possess sufficient operating flexibility to follow the weekly load schedule of a load following unit. This flexibility was obtained through the combined use of the boron thermal regeneration subsystem (BTRS) of the CHS (Section 9.3.4) and the boron recovery system.

Passage through the cesium removal ion exchangers, storage, evaporation, and demineralization constitutes the processing that the reactor coolant letdown can receive in the boron recovery system before discharge to the radioactive liquid waste system (Section 11.2). If the boron recovery system distillate is to be recycled to the primary grade water system (Section 9.2.8) or additional processing is required, additional demineralization and filtration may be performed. The bottoms from the boron evaporator are filtered and are capable of being sent either to the CHS for reuse or to the waste bottoms holding tank in the radioactive liquid waste system and ultimately to the radioactive solid waste system (Section 11.4) for solidification and shipment offsite. The waste bottoms holding tank is no longer in service and so no longer an option for receiving boron evaporator bottoms.

Reactor coolant, which previously passed through the mixed bed demineralizer in the CHS and was stripped of gases in the GWS (Section 11.3), is pumped through a cesium removal ion exchanger and a boron recovery filter. The two cesium removal ion exchangers provide an acceptable decontamination factor for removal of radio isotopes. The two cesium removal ion exchangers can be operated in series if required. From the cesium removal ion exchanger(s), the coolant is filtered by one of two boron recovery filters before passage to the boron recovery tanks.

The letdown is then stored in one of the two boron recovery tanks where it awaits further processing by the boron evaporator. The boron recovery tanks (150,000 gallons each) are sized so that, in conjunction with the boron evaporator (25 gpm), the boron recovery system provides the capability for meeting a wide range of unit operating conditions. The boron recovery tanks are located in a reinforced concrete diked area and covered with a metal siding enclosure. The boron recovery tanks are protected from freezing by external forced-circulation heating circuits, using electric boron recovery tank heaters and boron recovery tank heating pumps located adjacent to the tanks.

The liquid in the boron recovery tanks is pumped to the boron evaporator by one of two boron evaporator feed pumps. Either pump is able to supply the boron evaporator with feed in addition to supplying liquid, if necessary, to the high level waste drain tanks of the radioactive liquid waste system for processing and disposal.

The boron evaporator is constructed with an external reboiler, a vapor-liquid separator, and a tray section to reduce any liquid carryover to insignificant amounts and to maintain the boron content in the distillate at less than 5 ppm. For the specific design of the boron evaporator to be used in this unit, a decontamination factor for nonvolatiles of greater than 10^3 is calculated at a bottoms-to-feed concentration ratio greater than 1,000 (i.e., the worst condition for removal of radionuclides). Operation of the boron evaporator is automatic, based on selector control from the boron recovery panel in the auxiliary building. Manual bypass piping and controls are provided. Rapid drainage of the boron evaporator is provided by transferring the evaporator bottoms to the boron recovery tanks. Pump or reboiler maintenance may require emptying of the boron evaporator.

The boron evaporator distillate is collected in the boron distillate tank from which it is continuously removed on level control by the boron distillate pump, cooled in the boron distillate cooler, and discharged to one of the two boron test tanks. A small side stream from the boron distillate pump is utilized for reflux in the fractionating column of the boron evaporator.

Noncondensible gases (primarily resulting from absorption of nitrogen, xenon, and oxygen and from decay of iodine) which are removed from the liquid phase in the boron evaporator are discharged from the boron evaporator condenser and the boron distillate tank to the reactor plant aerated vents system (Section 9.3.3). The vent system combines these gases with the discharge from other vents and directs them to the radioactive gaseous waste system (Section 11.3).

The liquid discharged from the boron distillate tank fills one of the two boron test tanks (12,000 gallons each) in approximately 8 hours. After one of the test tanks is filled, flow is transferred to the other tank. The contents of the filled tank are mixed (by circulating the contents with a boron test tank pump), sampled, and discharged (Section 11.2.2.3) to the environment via the discharge line. These discharges occur when necessary to maintain a water balance within the unit or to control the tritium concentration within the reactor coolant system. However, the discharge activity, excluding tritium, from the boron recovery system to the discharge line is designed to not exceed the values given in the radioactive liquid waste system (Section 11.2).

The boron test tank liquid can also be sampled and if the boron content is suitable, pumped to a primary grade water storage tank (Section 9.2.8). Should the boron test tank contents require further reduction of the boron concentration, the contents are processed through the boron demineralizers, either one demineralizer or both in series, and filtered by the boron demineralizer filter prior to storage in the primary grade water storage tanks. If a decision to further reduce the boron concentration in the distillate is made after the primary grade water is transferred to the primary grade storage tanks, the contents of the primary grade storage tanks are circulated through the boron demineralizers and boron demineralizer filter.

Boron test tank contents can also be pumped to the high level waste drain tanks (Section 11.2.2.1) for processing in the radioactive liquid waste system.

Decontamination factors and retention times assumed for the analysis of the radionuclides in the boron distillate effluents are given in Table 9.3–8.

When the concentration of the boric acid in the boron evaporator bottoms is at the desired value of about 4 percent by weight, the reclaimed boric acid is pumped batch-wise through the boron evaporator bottoms cooler and the boron evaporator bottoms filters to the boric acid tanks in the CHS. The boron evaporator cooler reduces the bottoms temperature to about 170°F.

When packaging of the boron evaporator bottoms is desired for off site shipment, the boric acid concentration in the bottoms is increased to about 12 percent by weight. The bottoms are then pumped to the radioactive solid waste system for immobilization in a shipping container. The activities described in Section 11.4 are based on the relevant assumptions given in Table 9.3–8 and an average residence time of 1 week for the evaporator bottoms in the boron evaporator.

All piping in the boron recovery system containing liquids with greater than 4.1 percent by weight of boric acid is electrically heat traced to prevent precipitation of boric acid.

The control of each process in the boron recovery system is automatic once the system setpoints have been established by preoperational tests prior to startup. Operation of the boron evaporator is initiated from the boron recovery panel in the auxiliary building. Batch processing and proper sampling of liquids ensure control of boron recovery system effluent streams.

9.3.5.3 Safety Evaluation

The design criteria listed in Section 9.3.5.1 are met through the choice of boron recovery tankage and boron evaporator capacity. Because there is an interdependence between the sizing of the boron recovery tankage and the sizing of the boron evaporator, it is possible, within certain limits, to trade evaporator capacity for tankage. However, the design criteria place a boundary on the minimum size of tankage required, and this, in turn, determines the maximum evaporator capacity. Boron recovery tankage is 300,000 gallons and is supplied with a 25 gpm boron evaporator.

Removal of radioactive ions from the degassed letdown liquid is accomplished through the use of ion exchange, storage, and evaporation. Conservatism in design is evident in a comparison of the decontamination factors assumed in Table 9.3–8 with those obtained through actual plant operations and equipment design (Connecticut Yankee Operating Reports 1972 and Cohen 1969). For example, iodine is removed from borated solutions with decontamination factors which are often more than an order of magnitude greater than those assumed in the calculations. If required, the use of the boron demineralizers in series operation effects a higher decontamination factor for all radioactive ions. High decontamination factors are accomplished through the measurement and control of the interstage activity between the boron demineralizers.

Monitoring devices are provided to measure conditions of pressure, temperature, flow, and liquid level in the boron recovery system. These monitoring devices ensure that the boron recovery system is operated safely within design limits.

The boron evaporator is designed with an external reboiler, a large liquid disengaging space above the bottoms, a vapor-liquid separator, and a tray section to reduce carryover to a minimum. In addition, the boron evaporator is designed with a low vapor velocity throughout to further reduce any entrainment of liquid. Use of the boron evaporator yields a minimum decontamination factor of greater than 10^3 for nonvolatiles under the worst-case condition, where the bottoms-to-feed concentration ratio is greater than 1,000.

The performance of the boron recovery system is ensured through the overall design of the system. The use of equipment having high decontamination factors and of long retention times causes the system effluent activity to be considerably less than that required for discharge, even for the design basis case.

Heat tracing of boron recovery system piping containing liquids with greater than 4.1 weight percent boric acid provides protection against loss of solubility of boric acid.

Specific design requirements for tankage containing radioactive liquid is described in Section 11.2. Evaluation of the postulated failure of tankage containing radioactive liquid is described in Section 15.7.3.

A malfunction analysis of the boron recovery system is presented in Table 9.3–9.

9.3.5.4 Inspection and Testing Requirements

The boron recovery system is operated frequently during normal unit operation. This frequency of operation plus administrative control ensure the proper performance of boron recovery system components.

Routine preventive maintenance is performed on the system to ensure continued operation and system reliability.

9.3.5.5 Instrumentation Requirements

The boron recovery system operating parameters are monitored, indicated, and controlled from the boron recovery panel.

A boron recovery system trouble annunciator located on the main control board alarms whenever an alarm is activated on the boron recovery panel.

The following controls and instruments are located on the boron recovery panel:

Control switches and indicating lights for the following:

1. Boron evaporator feed pumps
2. Boron evaporator bottoms pump
3. Bottoms coolant pump
4. Bottoms coolant preheater feeder breaker
5. Boron evaporator reboiler pump
6. Distillate pump
7. Boron test tank pumps
8. Boron test tank divert valve
9. Boron demineralizer filter primary grade water divert valve
10. Boron evaporator bottoms pump inlet valve position indicating lights
11. Boron evaporator condenser vent valve control switch
12. Boron distillate tank vent valve

Annunciators that alarm when the following conditions exist in the boron recovery system:

1. Cesium removal ion exchanger differential pressure high
2. Boron recovery filter differential pressure High
3. Boron recovery tank liquid level High
4. Boron recovery tank liquid level Low
5. Boron recovery tank temperature Low
6. Boron evaporator liquid level Low
7. Boron evaporator pressure high
8. Distillate tank liquid level High
9. Distillate tank liquid level Low
10. Boron evaporator reboiler pump discharge pressure High
11. Boron evaporator reboiler pump discharge pressure Low
12. Boron evaporator reboiler pump seal water flow Low
13. Distillate pump seal water flow Low
14. Boron test tank temperature Low
15. Boron demineralizer filter differential pressure High
16. Boron demineralizer filter outlet conductivity High
17. Boron test tank level High
18. Boron test tank level Low
19. Distillate cooler outlet conductivity High
20. Boron evaporator bottoms pipe liquid level High
21. Boron evaporator bottoms pipe liquid level Low
22. Bottoms pump discharge pressure Low
23. Boron evaporator bottoms filter inlet temperature High

24. Boron evaporator bottoms filter inlet temperature Low
25. Boron evaporator bottoms filter differential pressure High
26. Boron evaporator bottoms cooler coolant preheater temperature Low
27. Boron evaporator bottoms cooler coolant preheater temperature High
28. Boron evaporator bottoms cooler coolant preheater feeder breaker auto trip
29. Bottoms pump seal water flow Low

Controllers with auto/manual feature and indication for the following:

1. Boron evaporator reboiler steam pressure control valve
2. Boron evaporator level control valve
3. Boron evaporator reboiler pump temperature controller
4. Boron distillate cooler temperature control valve
5. Boron evaporator reflux flow control valve
6. Boron evaporator condenser pressure control valve
7. Boron evaporator bottoms cooler coolant temperature control valve
8. Boron distillate tank level control valve

Indicators that monitor the following parameters in the boron recovery system:

1. Boron recovery tank liquid level
2. Boron evaporator tray differential pressure
3. Boron evaporator reboiler pump discharge pressure
4. Boron evaporator condenser noncondensible gas temperature
5. Boron evaporator bottoms pump discharge pressure
6. Boron evaporator bottoms to filter temperature
7. Boron evaporator bottoms drain pipe liquid level

8. Boron distillate cooler outlet conductivity

9. Boron test tank liquid level

The boron evaporator bottoms drain pipe liquid level is also indicated on the radioactive liquid waste panel.

Recorders are provided for the following:

1. Boron distillate cooler outlet conductivity

2. Boron demineralizer filter outlet conductivity

3. Boron evaporator liquid level

Multipoint recorders are provided for the following:

1. Boron evaporator feed flow

2. Boron evaporator reflux flow

3. Boron distillate tank inlet temperature

4. Boron evaporator temperature

5. Boron evaporator reboiler inlet temperature

6. Boron evaporator reboiler outlet temperature

7. Boron evaporator outlet temperature

8. Boron evaporator feed temperature

The following controls are located in the vicinity of the associated equipment:

1. Boron recovery tank heater control switch.

2. Boron test tank heater and boron bottoms coolant preheater control switches.

3. Control switches with indicating lights for the boron recovery tank heating pump and the boron test tank heating pump.

4. Boron recovery tank heater power on, and heater on indicating lights.

5. Control switches with indicating lights are also provided for the boron recovery tank and for the test tank heating pumps on the reactor plant sampling panel.

9.3.6 REFERENCES FOR SECTION 9.3

9.3-1 Cohen, P. 1969. Water Coolant Technology of Power Reactors, Chapter 7, Gordon & Breach, NY.

9.3-2 Connecticut Yankee Operating Reports (NUSCO). January 1970 - March 1972.

TABLE 9.3–1 SAMPLING POINTS – REACTOR PLANT

Sample System	Source Location
REACTOR COOLANT SYSTEM	
Reactor coolant hot legs	Containment
Reactor coolant cold legs	Containment
Pressurizer gas space	Containment
Pressurizer relief tank gas space	Containment
SAFETY INJECTION SYSTEM	
Accumulator	Containment
RESIDUAL HEAT REMOVAL SYSTEM	
RHR heat exchanger outlet	ESF building
CHS SYSTEM	
Reactor coolant filter inlet	Auxiliary Building
Letdown heat exchanger outlet	Auxiliary Building
Thermal regen demineralizer outlet	Auxiliary Building
Volume control tank gas	Auxiliary Building
Boric acid transfer pump discharge	Auxiliary Building
FUEL POOL COOL AND PURIFICATION SYSTEM	
Fuel pool demineralizer inlet	Auxiliary Building
Fuel pool demineralizer outlet	Auxiliary Building
PRIMARY GRADE WATER	
Storage tanks	Yard
QUENCH SPRAY SYSTEM	
Refueling water storage tank	Yard
BORON RECOVERY SYSTEM	
Boron recovery tanks (pump discharge)	Yard
Boron test tanks (pump discharge)	Yard
Boron demineralizer outlet	Auxiliary Building
RADIOACTIVE GASEOUS WASTE SYSTEM	
Process gas charcoal adsorber inlet	Auxiliary Building
Process gas charcoal adsorber “A” outlet and “B” inlet	Auxiliary Building

TABLE 9.3–1 SAMPLING POINTS – REACTOR PLANT (CONTINUED)

Sample System	Source Location
Process gas charcoal adsorber outlet	Auxiliary Building
RADIOACTIVE LIQUID WASTE SYSTEM	
High-level waste drain tanks	Waste Disposal
Low-level waste drain tanks	Waste Disposal
Waste bottom holding tank (removed from service)	Waste Disposal
Waste test tanks	Waste Disposal
Waste demineralizer outlet	Waste Disposal
Containment sump	Waste Disposal
Waste evaporator bottoms (removed from service)	Waste Disposal
RADIOACTIVE SOLID WASTE SYSTEM	
Cesium removal ion exchgr outlet	Waste Disposal
STEAM GENERATOR BLOWDOWN SYSTEM	
Each steam generator blowdown line (grab sample)	Containment
REACTOR PLANT COMPONENT COOLING WATER SYSTEM	
Main header	Auxiliary Building

NOTE:

Criteria for remote samples are given in Regulatory Guide 1.21.

TABLE 9.3–2 SAMPLING POINTS – TURBINE PLANT

Sample System	Source Location
Turbine plant component cooling water	Turbine Building
First point heaters	Turbine Building
Main steam 4	Turbine Building
Second point heater outlet	Turbine Building
Condensate	Turbine Building
Condenser hot well	Turbine Building
Sixth point heaters inlet (condensate)	Turbine Building
Condensate storage tank	Yard
Condensate surge tank	Yard
Demineralizer water storage tank	Yard
Turbine building floor drain sump	Turbine Building
Fourth point heater drain pumps	Turbine Building
Auxiliary feedwater and recirculation	Turbine Building
Fourth point heater outlet (condensate)	Turbine Building
Steam Generator blowdown lines (4 with continuous flow)	Main Steam Valve Building (Downstream of containment isolation valves 3BDG*CTV22A - D)

TABLE 9.3–3 POST-ACCIDENT SAMPLING SYSTEM PRINCIPAL COMPONENTS DESIGN AND PARAMETERS

Components	Design Parameters
Reactor Coolant Sample Module 3SSP-SAS1	
Number of Units	1
Capacity (gpm)	1
Design Pressure (psig)	2500
Design Temperature (°F)	165
Containment Air Sample Module 3SSP-SAS2	
Number of Units	1
Capacity (gpm)	0.4
Design Pressure (psig)	100
Design Temperature (°F)	300
Purge Skid 3SSP-SK2	
Number of Units	1
Tank Capacity (gal)	30
Pump Discharge Pressure (psig)	375
Pump Capacity (gpm)	1
Motor (hp)	1/3
Reactor Coolant Module Cooler 3SSP-SCL3	
Number of Units	1
Inlet Temperature (max °F)	650
Outlet Temperature (max °F)	165
Design Pressure (psig)	2500
Capacity (gpm)	1
Air Sample Pump 3SSP-P4	
Number of Units	1
Design Temperature (°F)	140
Design Pressure (psig)	100
Capacity (cfm)	1.35
Motor (hp)	3/4

TABLE 9.3–4 CHEMICAL AND VOLUME CONTROL SYSTEM DESIGN PARAMETERS

General	Parameters
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 at full power (°F)	556
Temperature of charging flow directed to reactor coolant system (°F)	517
Temperature of effluent directed to boron recycle system (°F)	115
Centrifugal charging pump bypass flow (each) (gpm)	60
Amount of 6600 ppm boric acid solution required to meet cold shutdown requirements shortly after full power operation (gallons)	28,352

TABLE 9.3–5 PRINCIPAL COMPONENT DATA SUMMARY

Centrifugal Charging Pumps		Summary
Number		3
Design pressure (psig)		2800
Design temperature (°F)		300
Design flow charging (gpm)		150
Design head, feet (at design charging flow)		5800
Material		Austenitic Stainless Steel
Boric Acid Transfer Pump		
Number		2
Design pressure (psig)		150
Design temperature (°F)		175
Design flow (gpm)		75
Design head, feet		235
Material		Austenitic Stainless Steel
Chiller Pumps		
Number		2
Design pressure (psig)		150
Design temperature (°F)		200
Design flow (gpm)		400
Design head, feet		150
Material		Carbon Steel
Regenerative Heat Exchanger		
General		
Number		1
Heat transfer rate at design conditions (BTU/hr)		11.0×10^6
Shell Side		
Design pressure (psig)		2485
Design temperature (°F)		650
Fluid		Borated Reactor Coolant

TABLE 9.3–5 PRINCIPAL COMPONENT DATA SUMMARY (CONTINUED)

Material		Austenitic Stainless Steel
Tube Side		
Design pressure (psig)		2735
Design temperature (°F)		650
Fluid		Borated Reactor Coolant
Material		Austenitic Stainless Steel
Operating Parameters (Normal):		
Shell Side (Letdown)		
Flow (lb/hr)		37,200
Inlet temperature (°F)		557
Outlet temperature (°F)		290
Tube Side (Charging)		
Flow (lb/hr)		27,300
Inlet temperature (°F)		130
Outlet temperature (°F)		517
Letdown Heat Exchanger		
General		
Number		1
Heat transfer rate at design conditions (BTU/hr)		16×10^6
Shell Side		
Design pressure (psig)		165
Design temperature (°F)		250
Fluid		Component Cooling Water
Material		Carbon Steel
Tube Side		
Design pressure (psig)		600
Design temperature (°F)		400
Fluid		Borated Reactor Coolant
Material		Austenitic Stainless Steel
Operating Conditions:		

TABLE 9.3–5 PRINCIPAL COMPONENT DATA SUMMARY (CONTINUED)

Shell Side	(Heatup Case) Design	Normal
Flow (lb/hr)	498,000	204,040
Inlet temperature (°F)	95	95
Outlet temperature (°F)	127	127
Tube Side (Letdown)		
Flow (lb/hr)	59,500	37,200
Inlet temperature (°F)	380 (max)	290
Outlet temperature (°F)	115	115
Excess Letdown Heat Exchanger		
Number		1
Heat transfer rate at design conditions (BTU/hr)		5.2×10^6
	Shell Side	Tube Side
Design pressure (psig)	185	2485
Design temperature (°F)	250	650
Design flow (lb/hr)	125,000	12,400
Inlet temperature (°F)	95	557
Outlet temperature (°F)	137	165
Fluid	Component Cooling Water	Borated Reactor Coolant
Material	Carbon Steel	Austenitic Stainless Steel
Seal Water Heat Exchanger		
Number		1
Heat transfer rate at design conditions (BTU/hr)		1.6×10^6
	Shell Side	Tube Side
Design pressure (psig)	165	150
Design temperature (°F)	250	250
Design flow (lb/hr)	125,000	66,000
Inlet temperature (°F)	95	139
Outlet temperature (°F)	108	115
Fluid	Component Cooling Water	Borated Reactor Coolant

TABLE 9.3–5 PRINCIPAL COMPONENT DATA SUMMARY (CONTINUED)

Material	Carbon Steel	Austenitic Stainless Steel
Moderating Heat Exchanger		
Number		1
Heat transfer rate at design conditions (BTU/hr)		2.53×10^6
	Shell Side	Tube Side
Design pressure (psig)	300	300
Design temperature (°F)	200	200
Design flow (lb/hr)	59,640	59,640
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)	123.1	131.7
Material	Austenitic Stainless Steel	Austenitic Stainless Steel
Letdown Chiller Heat Exchanger		
Number		1
Heat transfer rate at design conditions (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	59,640
Design inlet temperature (boron storage mode) (°F)	39	72.6
Design outlet temperature (boron storage mode) (°F)	48.4	45
Flow (boron storage mode) (lb⁄hr)	175,000	59,640

TABLE 9.3–5 PRINCIPAL COMPONENT DATA SUMMARY (CONTINUED)

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
Letdown Reheat Heat Exchanger		
Number		1
Heat transfer rate at design conditions (BTU/hr)		1.49×10^6
	Shell Side	Tube Side
Design pressure (psig)	300	600
Design temperature (°F)	200	400
Design flow (lb/hr)	59,640	44,730
Inlet temperature (°F)	115	280
Outlet temperature (°F)	140	246.7
Material	Austenitic Stainless Steel	Austenitic Stainless Steel
Volume Control Tank		
Number		1
Volume (ft^3)		400
Design pressure (psig)		75
Design temperature (°F)		250
Material		Austenitic Stainless Steel
Boric Acid Tank		
Number		2
Capacity, each (gallons)		23,400 (1)
Design pressure		Atmospheric
Design temperature (°F)		200
Material		Austenitic Stainless Steel
Batching Tank		
Number		1
Capacity (gal)		400

TABLE 9.3–5 PRINCIPAL COMPONENT DATA SUMMARY (CONTINUED)

Design pressure		Atmospheric
Design temperature (°F)		350
Material		Austenitic Stainless Steel
Chemical Mixing Tank		
Number		1
Volume (gal)		5
Design pressure (psig)		150
Design temperature (°F)		200
Material		Austenitic Stainless Steel
Chiller Surge Tank		
Number		1
Volume (gal)		500
Design pressure		Atmospheric
Design temperature (°F)		200
Material		Carbon Steel
Mixed Bed Demineralizers		
Number		2
Design pressure (psig)		300
Design temperature (°F)		250
Design flow (gpm)		120
Resin volume, each (ft^3)		30
Material		Austenitic Stainless Steel
Cation Bed Demineralizers		
Number		1
Design pressure (psig)		300
Design temperature (°F)		250
Design flow (gpm)		75
Resin volume (ft^3)		20
Material		Austenitic Stainless Steel
Thermal Regeneration Demineralizers		

TABLE 9.3–5 PRINCIPAL COMPONENT DATA SUMMARY (CONTINUED)

Number		5
Design pressure (psig)		300
Design temperature (°F)		250
Design flow (gpm)		200
Resin volume, each (ft^3)		74.3
Material		Austenitic Stainless Steel
Reactor Coolant Filter		
Number		1
Design pressure (psig)		300
Design temperature (°F)		300
Design flow (gpm)		150
Particle Retention		98 percent of 0.2 to 25 micron size or 6/40 composite
Material (vessel)		Austenitic Stainless Steel
Seal Water Injection Filters		
Number		2
Design pressure (psig)		3100
Design temperature (°F)		250
Design flow (gpm)		80
Particle Retention		98 percent of 5 micron size maximum
Material (vessel)		Austenitic Stainless Steel
Seal Water Return Filter		
Number		1
Design pressure (psig)		300
Design temperature (°F)		250
Design flow (gpm)		150
Particle Retention		98 percent of 25 micron size
Material (vessel)		Austenitic Stainless Steel
Letdown Filter		

TABLE 9.3–5 PRINCIPAL COMPONENT DATA SUMMARY (CONTINUED)

Number		1
Design pressure (psig)		300
Design temperature (°F)		250
Design flow (gpm)		150
Particle Retention		98 percent of > 6 micron size
Material (vessel)		Austenitic Stainless Steel
Boric Acid Filter		
Number		1
Design pressure (psig)		300
Design temperature (°F)		250
Design flow (gpm)		150
Particle Retention		98 percent of 25 micron size
Material (vessel)		Austenitic Stainless Steel
Letdown Orifice	45 gpm	75 gpm
Number	1	2
Design flow (lb/hr)	22,230	37,050
Differential pressure at design flow (psia)	1700	1700
Design pressure (psig)	2,485	2,485
Design temperature (°F)	650	650
Material	Austenitic Stainless Steel	Austenitic Stainless Steel
Chiller		
Number		1
Capacity (Btu/hr)		1.66×10^6
Evaporator Design flow (gpm)		352
Evaporator Inlet temperature (°F)		48.4
Evaporator Outlet temperature (°F)		39

NOTE:

1. Refer to Technical Specification 3.1.2.5 and 3.1.2.6 for BAT system requirements.

TABLE 9.3–6 FAILURE MODE AND EFFECTS ANALYSIS CHEMICAL AND VOLUME CONTROL SYSTEM ACTIVE COMPONENTS – NORMAL PLANT OPERATION AND SAFE SHUTDOWN

Component	Failure Mode	CHS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method **	Remarks
1. Air diaphragm-operated globe valve LCV459 (LCV460 analogous)	a. Fails open.	a. Charging and Volume Control - letdown flow.	a. Failure reduces redundancy, of providing letdown flow isolation to protect PRZ heaters from uncovering at low water level in PRZ. No effect on system operation. Alternate isolation valve (LCV-460) provides backup letdown flow isolation.	a. Valve position indicator (open to closed position change) at CB.	a. Valve is designed to fail “closed” and is electrically wired so that the electrical solenoid of the diaphragm operator is energized to open the valve. Solenoid is deenergized 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 closed manually from the CB if any of these valves are at an open position.

TABLE 9.3–6 FAILURE MODE AND EFFECTS ANALYSIS CHEMICAL AND VOLUME CONTROL SYSTEM ACTIVE COMPONENTS – NORMAL PLANT OPERATION AND SAFE SHUTDOWN (CONTINUED)

Component	Failure Mode	CHS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
	b. Fails closed.	b. Charging and Volume Control - letdown flow.	b. Failure blocks a 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 common mode failure (loss of instrument air supply) affecting the opening operation of isolation valves in each flow path, the plant operator can borate the RCS to a safe shutdown concentration level without letdown flow by taking advantage of the steam space available in the PRZ. Letdown can also be provided from the reactor vessel head.	b. Valve position indication (closed to open position change) at CB; letdown flow temperature indication (TI-127) at CB; letdown flow pressure indication (PI-131) at CB; letdown flow indication (FI-132) at CB; and VCT level indication (LI-112) and low water level alarm at CB.	
2. Air diaphragm-operated globe valve 8149B (8149C and 8149A analogous)	a. Fails open.	a. Charging and Volume Control - letdown flow.	a. Failure prevents isolation of normal letdown flow through regenerative heat exchanger. No effect safe shutdown operation. Containment isolation valve (8152 or 8160) may be remotely closed from the CB to isolate letdown flow through heat exchanger.	a. Valve position indication (open to closed position change) at CB.	1. Valve is of similar design as that stated for item number 1. Solenoid is deenergized to close the valve upon the generation of a low level PRZ signal or closing of letdown isolation valves (LCV459 and LCV460) upstream of the regenerative heat exchanger.

TABLE 9.3–6 FAILURE MODE AND EFFECTS ANALYSIS CHEMICAL AND VOLUME CONTROL SYSTEM ACTIVE COMPONENTS – NORMAL PLANT OPERATION AND SAFE SHUTDOWN (CONTINUED)

Component	Failure Mode	CHS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
	b. Fails closed.	b. Charging and Volume Control-letdown flow.	b. Failure blocks normal letdown flow to VCT. Normal letdown flow to VCT may be maintained by opening alternate letdown orifice isolation valve 8149C. Minimum letdown flow requirements for boration of RCS to safe shutdown concentration level may be met by opening letdown orifice isolation, valve 8149A or 8149C. If common mode failure (loss of instrument air) prevents opening of these valves also prevents establishing alternate flow through excess letdown flow path, plant operator can borate the RCS to a safe shutdown concentration level without letdown flow by taking advantage of steam space available in PRZ. Letdown can also be provided from the reactor vessel head.		
3. Air diaphragm-operated globe valve 8152 (8160 analogous)	a. Fails closed.	a. Charging and Volume Control-letdown flow.	a. Same effect on system operation as that stated for Item number 1, failure mode “Fails closed.”	a. Same methods of detection as those stated for item number 1 failure mode “Fails closed.” In addition, close position group monitoring light at CB.	1. Valve is of similar design as that stated for item Number 1. Solenoid is deenergized to close the valve upon the generation of an ESF “T” signal.

TABLE 9.3–6 FAILURE MODE AND EFFECTS ANALYSIS CHEMICAL AND VOLUME CONTROL SYSTEM ACTIVE COMPONENTS – NORMAL PLANT OPERATION AND SAFE SHUTDOWN (CONTINUED)

Component	Failure Mode	CHS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method **	Remarks
	b. Fails open.	b. Charging and Volume Control-letdown flow.	b. Failure has no effect on CHS operation during normal plant operation. However, under accident conditions requiring containment isolation, failure reduces the redundancy of providing isolation of normal letdown line.	b. Valve position indication (open) at CB.	
4. Air diaphragm-operated globe valve TCV-381B	a. Fails open.	a. Boron Concentration Control - boron thermal regeneration (boration).	a. Failure inhibits use of BTRS for load follow operation (boration) due to low temperature of letdown flow entering BIRS demineralizers. Alternate boration of reactor coolant is possible using RMCS of CHS. No effect on operation to bring reactor to safe shutdown condition.	a. Letdown heat exchanger tube discharge flow (FI-132) and pressure (PI-131) indications at CB and BTR demineralizer inlet flow temperature indication (TI-381) 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 CVCS systems used to bring the reactor to safe shutdown condition.
	b. Fails closed.	b. Boron Concentration Control - boron thermal regeneration (boration).	b. 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 RCS to safe shutdown concentration level may be met as stated for effect on system operation for item number 1, failure "Fails closed."	b. Same method of detection as those stated for item number 1, failure mode "Fails closed" except no "closed to open position change" indication at CB.	

TABLE 9.3–6 FAILURE MODE AND EFFECTS ANALYSIS CHEMICAL AND VOLUME CONTROL SYSTEM ACTIVE COMPONENTS – NORMAL PLANT OPERATION AND SAFE SHUTDOWN (CONTINUED)

Component	Failure Mode	CHS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
5. Air diaphragm-operated globe valve PCV-131	a. Fails open.	a. Charging and Volume Control - letdown flow.	a. 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 (8119) opens in demineralizer line to release pressure to VCT and valve (TCV-129) changes position to divert flow to VCT. Boration of RCS to safe shutdown concentration level is possible with valve failing open.	a. Letdown heat exchanger tube discharge flow indication (FI-132) and high flow alarm at CB; temperature indication (TI-130) and high temperature alarm at CB; and pressure indication (PI-131) at CB.	1. Same remark as stated for item Number 4, in regards to valve design.
	b. Fails closed.	b. Charging and Volume Control - letdown flow.	b. Same effect on system operation as that for item No. 1, failure mode “Fail closed.”	b. Letdown heat exchanger discharge flow indication (FI-132), and pressure indication (PI-131) and high pressure alarm at CB.	
6. Air diaphragm-operated three-way valve TCV-129	a. Fails open for flow only to VCT.	a. Charging and Volume Control - letdown flow.	a. Letdown flow bypassed from flowing to mixed bed demineralizers and BTRS. Failure prevents ionic purification of letdown flow and prevents operation of BTRS. Boration of RCS to safe shutdown concentration level is possible with valve failing open for flow only in VCT.	a. Valve position indication (VC Tank) at CB.	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.

TABLE 9.3–6 FAILURE MODE AND EFFECTS ANALYSIS CHEMICAL AND VOLUME CONTROL SYSTEM ACTIVE COMPONENTS – NORMAL PLANT OPERATION AND SAFE SHUTDOWN (CONTINUED)

Component	Failure Mode	CHS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method **	Remarks
	b. Fails open for flow only to mixed bed demineralizer.	b. Charging and Volume Control-letdown flow.	b. Continuous letdown to mixed bed demineralizers and BTRS. Failure prevents automatic isolation of mixed bed demineralizers and BTRS under condition of high letdown flow temperatures. Boration of RCS to safe shutdown concentration level is possible with valve failing open for flow only to demineralizers.	b. Valve position indication (Demin.) at CB. If BTRS is in operation, BTRS demineralizer return flow indication (FI-385).	
7. Air diaphragm-operated globe valve 8153.	a. Fails closed.	a. Charging and Volume Control - excess letdown flow.	a. Failure prevents use of the excess letdown line of the CHS as an alternate path that may be used for letdown flow control.	a. Valve position indication (closed to open position change) at CB and excess letdown heat exchanger outlet pressure indication (PI-124) and temperature indication (TI-122) at CB.	1. Valve is designed to fail “closed” and is electrically wired so that the electrical solenoid of air diaphragm is energized to open the valve. 2. If normal letdown and excess letdown flow is not available for safe shutdown operations, plant operator can borate RCS to safe shutdown concentration using steam space available in PRZ. Letdown can also be provided from the reactor vessel head.
	b. Fails open.	b. Charging and Volume Control - excess letdown flow.	b. Failure reduces redundancy of providing excess letdown flow isolation during normal plant operation and for plant startup. No effect on system operation.	b. Valve position indication (open to closed position change) at CB.	

TABLE 9.3–6 FAILURE MODE AND EFFECTS ANALYSIS CHEMICAL AND VOLUME CONTROL SYSTEM ACTIVE COMPONENTS – NORMAL PLANT OPERATION AND SAFE SHUTDOWN (CONTINUED)

Component	Failure Mode	CHS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method **	Remarks
8. Air diaphragm-operated globe valve HCV-123	a. Fails closed.	a. Charging and Volume Control - excess letdown flow.	a. Failure prevents use of excess letdown line of the CHS as an alternate path that may be used for letdown flow control.	a. Same methods of detection as those stated for item number 7, failure mode “Fails closed” except for no valve position indication at CB.	1. Same remarks as those stated above for item Number 7.
	b. Fails open.	b. Charging and Volume Control - excess letdown flow.	b. Failure prevents manual adjustment at CB of RCS system pressure downstream of excess letdown heat exchanger to a low pressure consistent with CVC seal return (CBO) backpressure requirements. Relief valve 8121 opens in seal return line to release pressure to PRT.	b. Excess letdown heat exchanger outlet pressure indication (PI-124) and temperature indication (TI-122) at CB.	
9. Motor-operated globe valve 8112 (8100 analogous)	a. Fails open.	a. Charging and Volume Control - seal water flow and excess letdown flow.	a. Failure has no effect on CHS operation during normal plant operation. However, under accident conditions requiring containment isolation of seal water flow and excess letdown flow, redundancy is reduced.	a. 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 an ESF “T” signal.

TABLE 9.3–6 FAILURE MODE AND EFFECTS ANALYSIS CHEMICAL AND VOLUME CONTROL SYSTEM ACTIVE COMPONENTS – NORMAL PLANT OPERATION AND SAFE SHUTDOWN (CONTINUED)

Component	Failure Mode	CHS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method **	Remarks
	b. Fails closed.	b. Charging and Volume Control - seal water flow and excess letdown flow.	b. RC pump seal water return flow and excess letdown flow blocked. Failure inhibits use of the excess letdown fluid system of the CHS as an alternate system that may be used for letdown flow control during normal plant operation. Relief valve 8121 provides capability of seal water in cooling RC pump bearings.	b. Valve position indication (closed to open position change) at CB; group monitoring light and alarm at CB; and seal water return flow recording (FR-154,156,158,160) and low seal water return at CB.	2. If normal letdown and excess letdown flow is not available for safe shutdown operation, plant operator can borate RCS to concentration using steam space available in PRZ.
10. Motor-operated gate valve 8105 (8106 analogous)	a. Fails open.	a. Charging and Volume Control - charging flow.	a. Failure has no effect on CHS operation during normal plant operation. However, under accident condition requiring isolation of charging line, failure reduces redundancy of providing isolation of normal charging flow.	a. Valve position indication (open to closed position change) at CB.	1. Valve is normally at a full open position and motor operation is energized to close the valve upon the generation of a Safety Injection “S” signal.

TABLE 9.3–6 FAILURE MODE AND EFFECTS ANALYSIS CHEMICAL AND VOLUME CONTROL SYSTEM ACTIVE COMPONENTS – NORMAL PLANT OPERATION AND SAFE SHUTDOWN (CONTINUED)

Component	Failure Mode	CHS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method **	Remarks
	b. Fails closed.	b. Charging and Volume Control - charging flow.	b. Failure prevents use of normal charging line to RCS for boration, dilution, and coolant makeup operations. Seal water injection path remains 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.	b. Valve position indication (closed to open position change) and group monitoring light (valve closed) at CB; letdown temperature indication (TI-127) and high-temperature alarm at CB; charging flow temperature indication (TI-126) at CB; charging pump discharge header pressure indicator (PI-120) at CB; VCT level indication (LI-112) and high-level alarm at CB.	
11. Air diaphragm-operated globe valve HCV-182	a. Fails open.	a. Charging and Volume Control - seal water flow.	a. Failure prevents manual adjustment at CB of seal flow.	a. Seal water injection flow indicator (FI-142A, 143A, 144A, 145A) at CB.	1. Same remark as that stated for item Number 4 in regards to design of valve.
	b. Fails closed.	b. Charging and Volume Control - seal water flow.	b. CCP cools reactor coolant pump thermal barrier to prevent seal failure.	b. Valve position indication (closed to open position change) at CB; group monitoring light and alarm at CB, seal water injection flow indicator (FI-142A,143A,144A, 145A) at CB.	

TABLE 9.3–6 FAILURE MODE AND EFFECTS ANALYSIS CHEMICAL AND VOLUME CONTROL SYSTEM ACTIVE COMPONENTS – NORMAL PLANT OPERATION AND SAFE SHUTDOWN (CONTINUED)

Component	Failure Mode	CHS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method **	Remarks
12. Motor-operated globe valve 8110 (8111 A,B,C analogous)	a. Fails open.	a. Charging and Volume Control - charging flow and seal water flow.	a. Failure has no effect on CHS operation during normal plant operation. However, under accident condition requiring isolation of centrifugal charging pump miniflow line, failure reduces redundancy of providing isolation of miniflow to suction of pump via seal water heat exchanger.	a. 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 safety injection signal.
	b. Fails closed.	b, Charging and Volume Control - charging flow and seal water flow.	b. Failure blocks miniflow to suction of centrifugal charging pumps via seal water heat exchanger. Normal charging flow and seal water 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 still possible.	b. Valve position indication (closed to open position change) at CB; group monitoring light (valve closed) and alarm at CB; and charging pump discharge header flow indicator (FI-121A) and high flow alarm at CB.	
13. Air diaphragm-operated globe valve 8146	a. Fails open.	a. Charging and Volume Control - charging flow.	a. Failure has no effect on CHS operation during normal plant operation or 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 PRZ will be extended.	a. Valve position indication (open to closed position change) at CB.	1.Same remarks as that stated for item Number 4 in regards to design of valve.

TABLE 9.3–6 FAILURE MODE AND EFFECTS ANALYSIS CHEMICAL AND VOLUME CONTROL SYSTEM ACTIVE COMPONENTS – NORMAL PLANT OPERATION AND SAFE SHUTDOWN (CONTINUED)

Component	Failure Mode	CHS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method **	Remarks
	b. Fails closed.	b. Charging and Volume Control - charging flow.	b. Failure block normal charging flow to the RCS. Plant operator can maintain charging flow by establishing flow through alternate charging path by opening of isolation valve (8147).	b. Valve position indication (closed to open position change) at CB; charging flow indication (TI-126) at CB; regenerative heat exchanger shell side exit temperature alarm at CB; and charging pump discharge header flow indicator (FI-121A) and low flow alarm at CB.	
14. Air diaphragm-operated globe valve 8147	a. Fails closed.	a. Charging and Volume Control - charging flow.	a. Failure reduces redundancy of charging flow paths to RCS. No effect on CHS operations during normal plant operation or safe shutdown operation. Normal charging flow path remains available for charging flow.	a. Valve position indication (closed to open position change) at CB.	1. Same remark as that stated for item Number 4 in regards to design of valve.
	b. Fails open.	b. Charging and Volume Control - charging flow.	b. Same effect on system operation and shutdown as that stated above for item number 14, failure mode "Fails open" if alternate charging line is in use.	b. Valve position indication (open to closed position change) at CB.	

TABLE 9.3–6 FAILURE MODE AND EFFECTS ANALYSIS CHEMICAL AND VOLUME CONTROL SYSTEM ACTIVE COMPONENTS – NORMAL PLANT OPERATION AND SAFE SHUTDOWN (CONTINUED)

Component	Failure Mode	CHS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method **	Remarks
15. Air diaphragm-operated globe valve 8145	a. Fails open.	a. Charging and Volume Control - charging flow.	a. Failure results in advertent operation of auxiliary spray that results in a reduction of PRZ pressure during normal plant operation. 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 safe shutdown condition is still possible.	a. Valve position indication (open to closed position change) at CB and PRZ pressure recording (PR-455) and low-pressure alarm at CB.	1. Same remark as that stated for item Number 7 in regards to design of valve.
	b. Fails closed.	b. Charging and Volume Control - charging flow.	b. Failure has no effect on CHS operation during normal plant operation. Valve is used during cold shutdown operation to activate auxiliary spray for cooling down the PRZ after operation of RHS.	b. Valve position indication (closed to open position change) at CB.	
16. Centrifugal charging pump 3CHS*P3A (Pumps P3B and P3C analogous)	a. Fails to deliver working fluid.	a. Charging and Volume Control - charging flow and seal water flow.	a. Failure reduces redundancy of providing charging and seal water flow to RCS. No effect on normal plant operation or bring reactor to a safe shutdown condition. Three pumps are provided, one being an installed spare.	a. Pump circuit breaker position indication (open) at CB; common pump breaker trip, alarm at CB; charging pump discharge header flow indicator (FI-121A) and low-flow alarm at CB. PRZ level recording (LR-459) and low-level alarm at CB.	1.Flow rate for a centrifugal charging pump is controlled by a modulating valve (FCV-121) in discharge header for the centrifugal charging pumps. (Note ***)

TABLE 9.3–6 FAILURE MODE AND EFFECTS ANALYSIS CHEMICAL AND VOLUME CONTROL SYSTEM ACTIVE COMPONENTS – NORMAL PLANT OPERATION AND SAFE SHUTDOWN (CONTINUED)

Component	Failure Mode	CHS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
17. Air diaphragm-operated globe valve 3GSH-PV48	a. Fails closed.	a. Chemical Control Purification and Makeup-oxygen control.	a. Failure blocks hydrogen flow to VCT resulting in loss of hydrogen overpressure. No effect on operation to bring the reactor to safe shutdown condition.	a. VCT pressure indication (PI-115) and periodic sampling of gas mixture in VCT.	
18. Motor-operated gate valve LCV-112B (LCV-112C analogous)	a. Fails open.	a. Charging and Volume Control - charging flow and seal water flow.	a. Failure has no effect on CHS operation during normal plant operation 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.	a. Valve position indication (open to closed position change) at CB.	1. During normal plant operation, valve is at a full open position and the motor operator is energized to close the valve upon the generation of a VCT low low water level signal or upon the generation of a Safety Injection “S” signal.
	b. Fails closed.	b. Charging and Volume Control - charging flow and seal water flow.	b. Failure blocks fluid flow from VCT during normal plant operation and when bringing the reactor to 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 (LCV-112D and LCV-112E).	b. Valve position indication (closed to open position change) at CB; group monitoring light (valve closed) at CB; charging pump discharge header flow indicator (FI-121A) and low-flow alarm at CB; and PRZ level recording (LR-459) and low-level alarm at CB.	

TABLE 9.3–6 FAILURE MODE AND EFFECTS ANALYSIS CHEMICAL AND VOLUME CONTROL SYSTEM ACTIVE COMPONENTS – NORMAL PLANT OPERATION AND SAFE SHUTDOWN (CONTINUED)

Component	Failure Mode	CHS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method **	Remarks
19. Air diaphragm-operated globe valve 8101 (8157 analogous)	a. Fails closed.	a. Chemical Control Purification and Makeup -oxygen control (8101), VCT pressure control (8157).	a. Failure blocks venting of VCT gas mixture to reactor plant gaseous drains for stripping of fission products from RCS coolant during normal plant operation. No effect on operations to bring the reactor to safe shutdown condition.	a. VCT pressure indication (PI-115) and high pressure alarm at CB. Periodic sampling of gas mixture in VCT.	1. Same remark as that stated for item Number 7 in regards to 810 valve design.
20. Air diaphragm-operated diaphragm valve FCV-110B	a. Fails closed.	a. Boron Concentration Control - reactor makeup control - boration, auto makeup, and alternate dilution.	a. Failure blocks fluid flow from reactor makeup control system for automatic boric acid addition and reactor water makeup during normal plant operation. Failure also reduces redundancy of fluid flow paths for dilution of RC coolant by reactor makeup water and blocks fluid flow for boration of the RC coolant when bringing the reactor to a safe shutdown condition. Boration (at BA tank boration concentration level) of RCS coolant to bring the reactor to a safe shutdown condition is possible by opening of alternate BA tank isolation valve (8104) at CB.	a. Valve position indication (closed to open position change) at CB; total makeup flow deviation alarm at CB; and VCT level indication (LI-112 and LI-185) and low level alarms at CB.	1. Same remark as that stated for item Number 7 in regards to valve design.
	b. Fails open.	b. Boron Concentration Control - reactor makeup control - boration, auto makeup, and alternate dilution.	b. Failure allows for alternate dilute mode type operation for system operation of normal dilution of RCS coolant. No effect on CHS operation during normal plant operation and bringing the reactor to a safe shutdown condition.	b. Valve position indication (open to closed position change) at CB.	

TABLE 9.3–6 FAILURE MODE AND EFFECTS ANALYSIS CHEMICAL AND VOLUME CONTROL SYSTEM ACTIVE COMPONENTS – NORMAL PLANT OPERATION AND SAFE SHUTDOWN (CONTINUED)

Component	Failure Mode	CHS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method **	Remarks
21. Air diaphragm-operated diaphragm valve FCV-111B	a. Fails closed.	a. Boron Concentration Control - reactor makeup control - dilution and alternate dilution.	a. Failure blocks fluid flow from RMCS for dilution of RCS coolant during normal plant operation. No effect on CHS 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 safe shutdown position.	a. Same methods of detection as those stated above for item No. 21 failure mode “Fails closed.”	1. Same remark as that stated for item Number 7 in regards to valve design.
	b. Fails open.	b. Boron Concentration Control - reactor make up control - dilution and alternate dilution.	b. Failure allows for alternate dilute mode type operation for system operation of boration and auto makeup of RCS coolant. No effect on CHS operation during normal plant operation and when bringing the reactor to a safe shutdown condition.	a. Valve position indication (open to closed position change) at CB.	
22. Air diaphragm-operated globe valve FCV-110A	a. Fails open.	a. Boron Concentration Control - reactor makeup control-boration and auto makeup.	a. Failure prevents the addition to a preselected quantity of concentrated boric acid solution at a preselected flow rate to the RCS coolant during normal plant operation 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.	a. Valve position indication (open to closed position change) at CB; and boric acid flow recording (FR-110) and flow deviation alarm at CB.	1. Same remark as that stated for item Number 4 in regards to valve design.

TABLE 9.3–6 FAILURE MODE AND EFFECTS ANALYSIS CHEMICAL AND VOLUME CONTROL SYSTEM ACTIVE COMPONENTS – NORMAL PLANT OPERATION AND SAFE SHUTDOWN (CONTINUED)

Component	Failure Mode	CHS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method **	Remarks
	b. Fails closed.	b. Boron Concentration Control - reactor makeup control - boration, and auto makeup.	b. Failure blocks fluid flow of boric acid solution from BA tanks during normal operation 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 is possible by opening of alternate BA tank isolation valve (8104) at CB.	b. Valve position indication (closed to open position change) at CB; and boric acid flow recording (FR-110) and flow deviation alarm at CB.	
23. Air diaphragm-operated globe valve FCV-111A	a. Fails closed.	a. Boron Concentration Control - reactor makeup control - dilute, alternate dilute, and auto makeup.	a. Failure blocks fluid flow of water from reactor makeup control system during normal plant operation. No effect on system operation when bringing the reactor to a safe shutdown condition.	a. VCT level indication (LI-112 and LI-185) and low water level alarms at CB; and makeup water flow recording (FR-110) and flow deviation alarm at CB.	1. Same remark as that stated for item Number 7 in regards to valve design.
	b. Fails open.	b. Boron Concentration Control - reactor makeup control - dilute, alternate dilute, and auto makeup.	b. Failure prevents the addition of a preselected quantity of water makeup at a preselected flow rate to the RCS coolant during normal plant operation. No effect on system operation when bringing the reactor to a safe shutdown condition.	a. Makeup water flow recording (FR-110) and flow deviation alarm at CB.	

TABLE 9.3–6 FAILURE MODE AND EFFECTS ANALYSIS CHEMICAL AND VOLUME CONTROL SYSTEM ACTIVE COMPONENTS – NORMAL PLANT OPERATION AND SAFE SHUTDOWN (CONTINUED)

Component	Failure Mode	CHS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method **	Remarks
24. Motor-operated globe valve 8104	a. Fails closed.	a. Boron Concentration Control Emergency Boration.	a. Failure reduces redundance of flow paths for supplying boric acid solution from BA tanks to RCS via charging pumps. No effect on CHS operation during normal plant operation or safe shutdown operation. Normal flow path via RMCS remains available for boration of RCS coolant.	a. Valve position indication (closed to open position change) at CB and flow indication (FI-183A) 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 (FCV-110A and 8104), borated water from RWST is available opening isolation valve LCV-112D or LCV-112E.
	b. Fails open.	b. Boron Concentration Control - reactor makeup control - boration and auto makeup.	b. 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, 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.	b. Valve position indication (open to closed position change) at CB and flow indication (FI-183A) or CB.	
25. Boric acid transfer pump 3CHS*P2A (BA transfer pump P2B analogous)	a. Fails to deliver working fluid.	a. Boron Concentration Control - reactor makeup control - boration and auto makeup.	a. No effect on CHS system operation during normal plant operation or bringing reactor to safe shutdown condition. Alternate BA transfer pump P2B may be used to provide necessary delivery of working fluid for CHS system operation.	a. Pump motor start relay position indication (open) at CB and local pump discharge pressure indication (PI-113).	

TABLE 9.3–6 FAILURE MODE AND EFFECTS ANALYSIS CHEMICAL AND VOLUME CONTROL SYSTEM ACTIVE COMPONENTS – NORMAL PLANT OPERATION AND SAFE SHUTDOWN (CONTINUED)

Component	Failure Mode	CHS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method **	Remarks
26. Air diaphragm-operated three-way valve LCV-112A	a. Fails open for flow only to Boron Recovery Tank.	a. Charging and Volume Control - letdown flow.	a. Failure bypasses normal down flow Boron Recovery Tank resulting in excessive use of RMCS. No effect on operation to bring reactor to safe shutdown condition.	a. Valve position (Holdup Tank) at CB; VCT water level indication (LI-185 and LI-112) and low level alarms at CB; and increase water level in BRS recycle holdup tank.	1. 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 Boron Recovery Tank. Valve opens to flow to Boron Recovery Tank on high VCT water level signal.
27. Air diaphragm-operated globe valve FCV-121	a. Fails open.	a. Charging and Volume Control - charging flow.	a. Failure prevents manual adjustment at CB of charging flow results in an increased flow via the normal CHS charging line and a reduction of flow to the 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 possible through normal charging flow paths.	a. High PRZ level indication and alarm at CB. Charging Pump Discharge Header Flow Indicator (FI-121A) and high alarm at CB.	1. Same remark as that stated for item Number 4 in regards to design of valve.

TABLE 9.3–6 FAILURE MODE AND EFFECTS ANALYSIS CHEMICAL AND VOLUME CONTROL SYSTEM ACTIVE COMPONENTS – NORMAL PLANT OPERATION AND SAFE SHUTDOWN (CONTINUED)

Component	Failure Mode	CHS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks
	b. Fails closed.	b. Charging and Volume Control - charging flow.	b. Failure prevents use of normal charging line to RCS for boration, dilution, and coolant makeup operations. Seal water injection path remains available for boration of RCS to a safe shutdown concentration and makeup of coolant during operations to bring the reactor to a safe shutdown condition.	b. Valve position indication (open to closed position change) at CB; letdown temperature indication (TI-127) and high temperature alarm at CB; Charging Pump Discharge Header Flow Indicator (FI-121A) and low alarm at CB. VCT level indication (LI-112 and LI-185) and high-level alarm at CB. PRZ, decreasing level, at CB.	

TABLE 9.3–6 FAILURE MODE AND EFFECTS ANALYSIS CHEMICAL AND VOLUME CONTROL SYSTEM ACTIVE COMPONENTS – NORMAL PLANT OPERATION AND SAFE SHUTDOWN (CONTINUED)

Component	Failure Mode	CHS Operation Function	Effect on System Operation and Shutdown*	Failure Detection Method**	Remarks

* List of acronyms and abbreviations used:

BA – Boric Acid
BRS – Boron Recovery System
BTR – Boron Thermal Regeneration
BTRS – Boron Thermal Regeneration System
CB – Control Board
CHS – Chemical and Volume Control System
Demin.– Demineralizer
HX – Heat Exchanger
PRZ – Pressurizer
RC – Reactor Coolant
RCS – Reactor Coolant System
RHS – Residual Heat Removal System
RWST – Refueling Water Storage Tank
RMCS – Reactor Makeup Control System
VCT – Volume Control Tank

** Equipment performance is monitored as part of plant operation, periodic tests, surveillance inspections, and instrument calibrations. Failures may be detected during such monitoring of equipment in addition to Failure Detection Method notes.

*** Certain initiating HELB events, postulated to occur in the operating CHS pump discharge piping, when combined with a single active failure of the standby CHS pump to start, may lead to a loss of all charging. In addition, all charging may be lost as a result of certain postulated fire conditions (See FSAR Section 9.5.1 and the FPER for SIH system performance requirements). For these conditions, the SIH pumps will provide the required RCS inventory and boration flow to achieve safe shutdown.

TABLE 9.3–7 BORON RECOVERY SYSTEM PRINCIPAL COMPONENT DESIGN AND PERFORMANCE CHARACTERISTICS

	Characteristics
Boron Evaporator	
Number	1
Design Capacity (gpm)	25
Design pressure (psig)	100/full vacuum
Design temperature (°F)	350
Material of construction	Stainless steel
Boron Recovery Tanks	
Number	2
Design Capacity (gal)	150,000
Design pressure (psig)	Atmospheric/full liquid
Design temperature (°F)	180
Material of construction	Stainless steel
Boron Test Tanks	
Number	2
Design Capacity (gal)	12,000
Design pressure (psig)	Atmospheric/full liquid
Design temperature (°F)	150
Material of construction	Stainless steel
Boron Distillate Tank	
Number	1
Design Capacity (gal)	300
Design pressure (psig)	100/full vacuum
Design temperature (°F)	340
Material of construction	Stainless steel
Cesium Removal Ion Exchangers	
Number	2
Resin volume (ft^3)	35
Design pressure (psig)	200

TABLE 9.3–7 BORON RECOVERY SYSTEM PRINCIPAL COMPONENT DESIGN AND PERFORMANCE CHARACTERISTICS (CONTINUED)

	Characteristics
Design temperature (°F)	300
Material of construction	Stainless steel
Boron Demineralizers	
Number	2
Resin volume (ft^3)	35
Design pressure (psig)	150
Design temperature (°F)	140
Material of construction	Stainless steel
Boron Recovery Filters	
Number	2
Design capacity (gpm)	200
Design pressure (psig)	200
Design temperature (°F)	300
Material of construction	Stainless steel
Boron Evaporator Bottom Filters	
Number	2
Design capacity (gpm)	50
Design pressure (psig)	200
Design temperature (°F)	300
Material of construction	Stainless steel
Boron Demineralizer Filter	
Number	1
Design capacity (gpm)	200
Design pressure (psig)	150
Design temperature (°F)	140
Material of construction	Stainless steel
Boron Distillate Cooler	
Number	1
Duty (Btu/hr)	1,632,500

TABLE 9.3–7 BORON RECOVERY SYSTEM PRINCIPAL COMPONENT DESIGN AND PERFORMANCE CHARACTERISTICS (CONTINUED)

	Characteristics
Material of construction	Stainless steel
Distillate (shell)	
Capacity (lb/hr)	12,500
Operating pressure (psig)	50
Design pressure (psig)	150
Design temperature (°F)	274
Operating temperature, in/out (°F)	250/120
Reactor Plant Component Cooling Water (tube)	
Capacity (lb/hr)	81,625
Operating pressure (psig)	167
Design pressure (psig)	175
Design temperature (°F)	274
Operating temperature, in/out (°F)	95/115
Boron Evaporator Boiler	
Number	1
Duty (Btu/hr)	15,395,125
Saturated Steam (shell)	
Capacity (lb/hr)	17,484
Operating pressure (psig)	100
Design pressure (psig)	180
Design temperature (°F)	400
Operating temperature, in/out (°F)	338/338
Material of construction	Carbon steel
Borated Water (tube)	
Capacity (lb/hr)	1,375,000
Operating pressure (psig)	25
Design pressure (psig)	100
Design temperature (°F)	350
Operating temperature, in/out (°F)	253/264

TABLE 9.3–7 BORON RECOVERY SYSTEM PRINCIPAL COMPONENT DESIGN AND PERFORMANCE CHARACTERISTICS (CONTINUED)

	Characteristics
Material of construction	Stainless steel
Boron Evaporator Condenser	
Number	1
Duty (Btu/hr)	13,010,250
Material of construction	Stainless steel
Saturated steam (shell)	
Capacity (lb/hr)	13,750
Operating pressure (psig)	15
Design pressure (psig)	100
Design temperature (°F)	350
Operating temperature, in/out (°F)	250/250
Reactor Plant Component Cooling Water (tube)	
Capacity (lb/hr)	650,512
Operating pressure (psig)	125
Design pressure (psig)	240
Design temperature (°F)	350
Operating temperature, in/out (°F)	95/115
Boron Evaporator Bottoms Cooler (3BRS-E5)	
Number	1
Duty (Btu/hr)	637,500
Cooling water (shell)	
Capacity (lb/hr)	63,750
Operating pressure inlet (psig)	207
Design pressure (psig)	210
Operating temperature, in/out (°F)	140/150
Material of construction	Carbon steel
Borated water (tube)	
Capacity (lb/hr)	7,500
Operating pressure inlet (psig)	50

TABLE 9.3–7 BORON RECOVERY SYSTEM PRINCIPAL COMPONENT DESIGN AND PERFORMANCE CHARACTERISTICS (CONTINUED)

	Characteristics
Design pressure (psig)	170
Operating temperature, in/out (°F)	255/170
Material of construction	Stainless steel
Boron Bottoms Coolant Preheater (3BRS-E6)	
Number	1
Total duty (kW)	90
Capacity (gpm)	150
Design pressure (psig)	263
Design temperature, in/out (°F)	140/185
Operating pressure (psig)	100
Material of construction	Carbon steel
Boron Test Tank Heaters	
Number	2
Total duty (kW)	3
Capacity (gpm)	75
Design pressure (psig)	50
Operating pressure (psig)	30
Design temperature, in/out (°F)	40/100
Material of construction	Stainless steel
Boron Recovery Tank Heater	
Number	2
Total duty (kW)	7
Design capacity (gpm)	75
Design pressure (psig)	50
Operating pressure (psig)	30
Design temperature, in/out (°F)	40/100
Material of construction	Stainless steel
Boron Evaporator Feed Pumps	
Number	2

TABLE 9.3–7 BORON RECOVERY SYSTEM PRINCIPAL COMPONENT DESIGN AND PERFORMANCE CHARACTERISTICS (CONTINUED)

	Characteristics
Design capacity (gpm)	50
Design head (ft.)	90
Pump casing design pressure (psig)	350
Pump casing design temperature (°F)	250
Material of construction	Stainless steel
Boron Distillate Pump	
Number	1
Design capacity (gpm)	30
Design head (ft.)	62.9
Pump casing design pressure (psig)	350
Pump casing design temperature (°F)	250
Material of construction	Stainless steel
Boron Evaporator Bottoms Pump	
Number	1
Design capacity (gpm)	15
Design head (ft.)	122.1
Pump casing design pressure (psig)	350
Pump casing design temperature (°F)	250
Material of construction	Stainless steel
Boron Test Tank Pump	
Number	2
Design capacity (gpm)	50
Design head (ft.)	223
Pump casing design pressure (psig)	350
Pump casing design temperature (°F)	250
Material of construction	Stainless steel
Boron Evaporator Reboiler Pump	
Number	1
Design capacity (gpm)	2,750

TABLE 9.3–7 BORON RECOVERY SYSTEM PRINCIPAL COMPONENT DESIGN AND PERFORMANCE CHARACTERISTICS (CONTINUED)

	Characteristics
Design head (ft.)	60
Pump casing design pressure (psig)	600
Pump casing design temperature (°F)	350
Material of construction	Stainless steel
Boron Bottoms Coolant Pump	
Number	1
Design capacity (gpm)	120
Design head (ft.)	7.5
Pump casing design pressure (psig)	350
Pump casing design temperature (°F)	250
Material of construction	Stainless steel
Boron Test Tank Heating Pump	
Number	2
Design capacity (gpm)	60
Design head (ft.)	62.4
Pump casing design pressure (psig)	350
Pump casing design temperature (°F)	250
Material of construction	Stainless steel
Boron Recovery Tank Heating Pump	
Number	2
Design capacity (gpm)	60
Design head (ft.)	62.4
Pump casing design pressure (psig)	350
Pump casing design temperature (°F)	250
Material of construction	Stainless steel

TABLE 9.3–8 ASSUMPTIONS USED IN ACTIVITY DISCHARGE CALCULATIONS

Decontamination Factors	I	Cs/Rb	Other
Cesium Removal Ion Exchangers	10	2	10
Boron Evaporator (Does not include boron demineralizers)	100	1,000	1,000
Boron Demineralizer	1	1	1
TOTAL	1,000	2,000	10,000

Retention Times

Boron recovery system 68.97 days

Letdown flow rate 75 gpm

TABLE 9.3–9 BORON RECOVERY SYSTEM FAILURE ANALYSIS

Component	Malfunction	Comments and Consequences
Pressure vessels and other components containing letdown liquids with dissolved gases	Outleakage	Pressure vessel and other components are protected from overpressure by automatic controls and relief valves; therefore, only minor leaks are considered possible.
Boron recovery tanks	Outleakage	Only degassed liquids are normally stored in these tanks which are protected by a diked area capable of retaining the entire contents of the tanks.
One boron recovery evaporator and auxiliaries	Failure to function	Sufficient capability to make boric acid solution for station requirements exist in the boric acid batch tanks, and the primary water tanks can supply adequate quantities of water.

FIGURE 9.3–1 (SHEETS 1-4)P&ID COMPRESSED AIR SYSTEM

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.3–2 (SHEETS 1-4) P&ID REACTOR PLANT SAMPLING SYSTEM

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.3–3 (SHEETS 1-2) P&ID TURBINE PLANT SAMPLING

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.3–4 (SHEETS 1-2) P&ID RADIOACTIVE GASEOUS WASTE SYSTEM

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.3–5 P&ID REACTOR PLANT GASEOUS DRAINS

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.3–6 (SHEETS 1-3) P&ID RADIOACTIVE LIQUID WASTE AND AERATED DRAIN

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.3–7 P&ID REACTOR COOLANT PUMP SEALS (SHEET 1)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.3–7(1)(A) REACTOR COOLANT PUMP SEALS (TEMP/MOD)

MNPS-3 FSAR

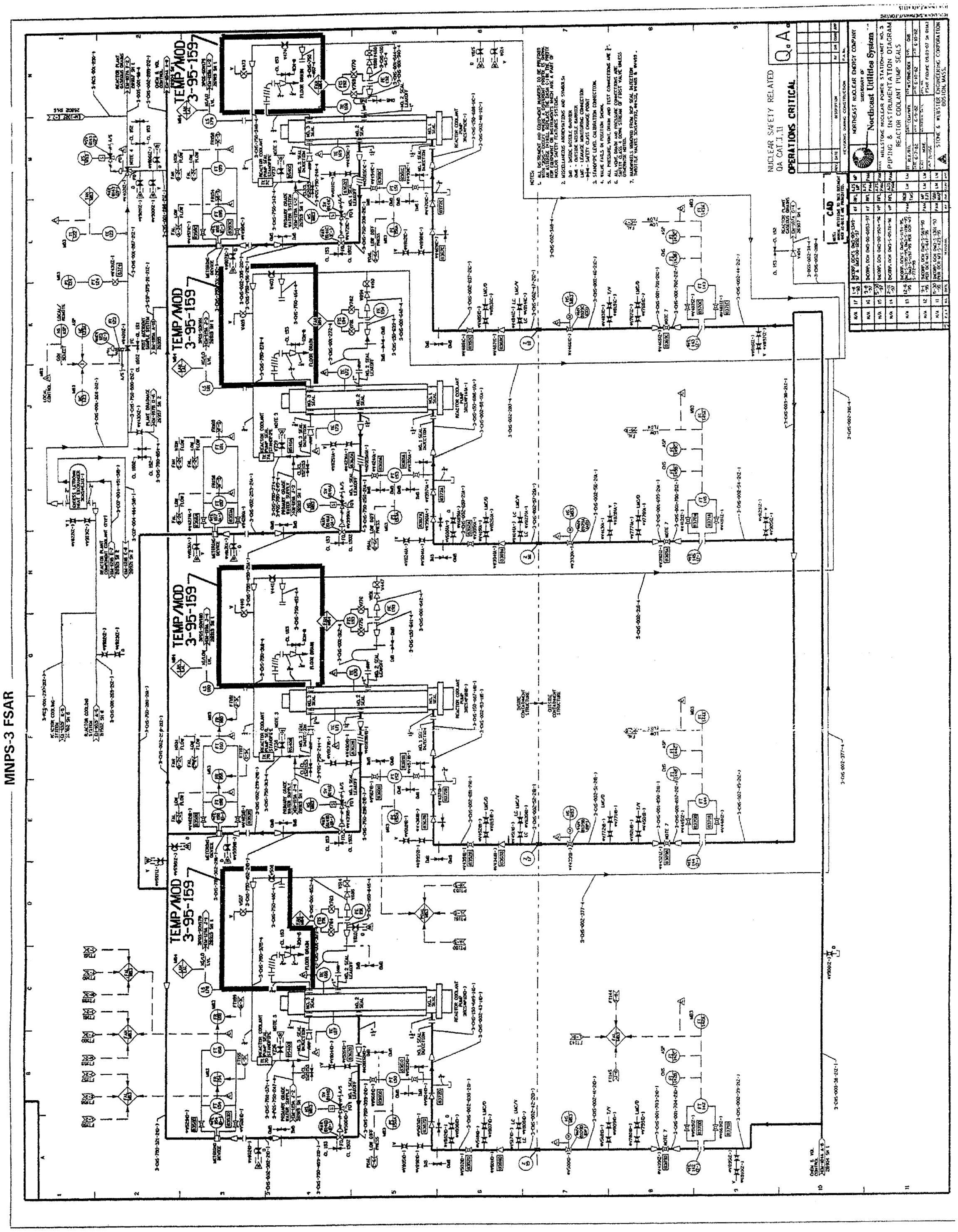


FIGURE 9.3–8 (SHEETS 1-4) P&ID CHEMICAL AND VOLUME CONTROL

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.3–9 (SHEETS 1-3) P&ID BORON RECOVERY SYSTEM

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

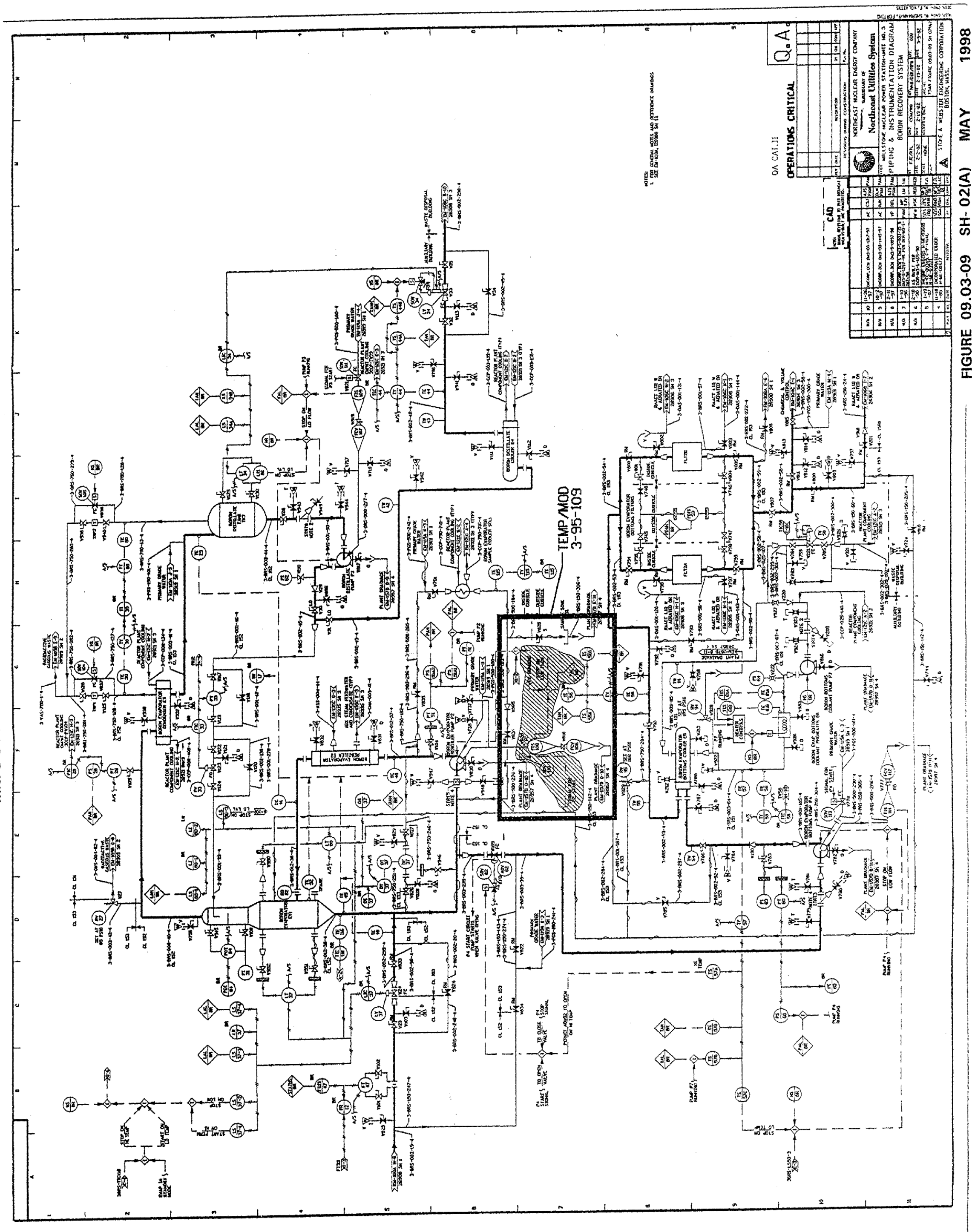


FIGURE 9.3–9(2)(A) BORON RECOVERY SYSTEM (TEMP/MOD)

FIGURE 9.3–10 (SHEETS 1-3)P&ID POST ACCIDENT SAMPLE SYSTEM

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

9.4 AIR CONDITIONING, HEATING, COOLING, AND VENTILATION SYSTEMS

Throughout Section 9.4, design values are used for space temperatures (dry bulb (db) or wet bulb (wb)), relative humidity, chilled water temperature, service water temperature, hot water temperature, air flow rate (cfm), differential pressure (dp), and various cooling/heating water flow (gpm). These values represent nominal values that were used in initial calculations to estimate the heating ventilation and air conditioning (HVAC) systems requirements. Since these are nominal design values, however, actual operating values during plant operations may vary.

HVAC systems are designed to maintain acceptable room conditions for human comfort and equipment environmental qualifications. HVAC equipment is sized to maintain a particular nominal design value at some specific dependent parameters, such as outdoor air temperature, total system resistance (pressure drop), temperature differential across cooling coils, or heat gain/loss calculation results. The nominal design value represents a specific point of operation which normally takes into account the most limiting dependent parameters, and is not, necessarily, the setpoint value at which the HVAC equipment is required to operate or the space conditions are to be maintained. HVAC equipment operation and space conditions are maintained within an acceptable range as determined by engineering. In specific cases, the nominal design value appears with such qualifiers as: less than, greater than, not to exceed, minimum, or maximum. For example, design air flow rates depicted in the FSAR are nominal design values without any qualifiers, whereas the actual air flow rate can vary by ± 10 percent as determined by engineering in the acceptance criteria of the air balancing procedure.

9.4.0 DESIGN TEMPERATURE BASES

The design basis temperatures for Millstone Unit 3 HVAC are based on the 1972 American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Design Weather Data for New London, CT. The summer and winter outdoor design temperatures selected for Millstone Unit 3 are as follows:

Season	**Temperature**	**Source**
Winter	0°F dry bulb	ASHRAE 1972, Weather Data and Design Conditions, page 671
Summer	86°F dry bulb 75°F wet bulb	ASHRAE 1972, Weather Data and Design Conditions, page 671

Typically, nuclear power plants use 99% winter design temperature which represents the temperature that has been equaled or exceeded by 99% of the total hours in the average winter months of December, January, February (a total 2160 hours). In New London, CT this is 4°F (Ref. source, column 4, winter, 99%). A more conservative design winter temperature of 0°F is selected for Millstone Unit 3. Temperatures less than 0°F will occur for less than 22 hours in an average winter.

The summer outdoor design temperature of 86°F db and 75°F wb (Ref. source summer, column 6 and 8) represent values that are exceeded 2.5% of the total summer hours of 2928; i.e., 73 hours and is used for sizing of HVAC equipment.

For a statistically average summer, the magnitude of the outdoor temperature excursion beyond 86°F for 73 hours is taken as the average of the maximum values recorded for the Bridgeport area over a 30 year period. This equals 93°F. The application of this temperature over the 40 year life of the plant for equipment qualification is discussed in Appendix 3B. Climatological data for Bridgeport and Millstone, Tables 2.3–1 and 2.3–19 show maximum ever recorded temperatures of 103°F and 91°F, respectively. 103°F was selected as a one time occurrence in the life of the plant and its application for equipment qualification is discussed in Appendix 3B. Outdoor winter temperature excursions below 0°F and the associated indoor temperature excursions do not adversely affect equipment qualification and are not considered.

Indoor design temperatures for the various areas of the plant are defined in the sections which follow. Indoor temperature excursions above the summer temperature are reflected in the temperature profile of Appendix 3B of Section 3.11 which are used in the environmental qualification of safety related electrical equipment. Indoor design temperatures excursions will occur along with outdoor air temperature excursions for the average 73 hour periods. However, temperature excursions are partially mitigated by thermal inertia effects of heavy concrete structures, and by the type of HVAC (e.g., air conditioning, once through ventilation or variations in between). Critical areas containing equipment required for safety related functions are monitored by installed instrumentation and alarms and/or inspected on a periodic basis. Abnormal temperature conditions will be monitored, evaluated and corrected by operators actions.

9.4.1 CONTROL BUILDING VENTILATION SYSTEM

The control building ventilation system consists of air conditioning, heating, filtration, and ventilation subsystems which provide a suitable environment for the comfort and safety of personnel within the control room area; and facilitates removal of equipment generated heat except for the chiller and cable spreading areas.

9.4.1.1 Design Bases

The control building ventilation system design is based on the following criteria.

1. General Design Criterion 2 (Section 3.1.2.2) for protection against natural phenomena.

2. General Design Criterion 4 for protection against temperature, pressure, humidity, and accident conditions.

3. General Design Criterion 19 for providing adequate radiation protection for control room personnel under accident conditions except as stated in Section 3.1.2.19.

4. General Design Criterion 5 for shared systems and components important to safety.

5. Regulatory Guide 1.52 for air filtration requirement.

6. Regulatory Guide 1.95 for protection of nuclear plant control room operators against an accidental chlorine release.

7. Regulatory Guide 1.78 for assumptions for evaluating the habitability of the control room following postulated chemical release.

8. Regulatory Guide 1.26 for the Quality Group Classifications of systems and components.

9. Regulatory Guide 1.29 for the seismic design classification of system components.

10. Instrumentation and controls, required to perform a safety function and located in the control building, are qualified to environmental conditions in accordance with IEEE 323-1974 as described in Section 3.11.

11. The range of indoor design temperatures during normal and abnormal plant conditions as given in Table 9.4–1.

9.4.1.2 System Description

Figure 9.4–1 shows the control building air conditioning, filtration, ventilation, and chilled water systems. Table 9.4–2 lists the principal components and approximate parameters.

The following control building air conditioning and ventilation subsystems are provided.

1. The control room air conditioning subsystem consists of two redundant 100 percent capacity air conditioning units, each containing a fan, cooling coil, an electric heating element, and filter. Each unit is rated at 21,725 cfm. A humidifier maintains a minimum humidity level in winter.

2. The instrument rack and the computer room air conditioning subsystem consists of two redundant 100 percent capacity air conditioning units, each containing a fan, cooling coil, an electric heating element, and filter. Each unit is rated at 32,300 cfm. A humidifier maintains a minimum humidity level in winter.

3. Each of the two switchgear areas has a separate air conditioning subsystem consisting of two air conditioning units. For each air conditioning subsystem, depending upon the cooling load needed, one or two air conditioning units operate to filter, cool, and deliver up to 31,000 cfm air to the distribution ductwork and finally into the area.

4. The chiller equipment space ventilation subsystem consists of two redundant 100 percent capacity supply and exhaust fans for heat dissipation and two electric heating elements. Each fan is rated at 2,000 cfm and, when operated together, can purge the chiller equipment space in the event of refrigerant discharge.

5. The control room toilet and kitchenette exhaust ventilation subsystem consists of an exhaust fan, which is rated at 595 cfm.

6. The purge ventilation subsystem consists of a supply and exhaust fan. Each fan is rated at 4,000 cfm.

7. Each battery room has an independent exhaust fan and associated ductwork. Air to these areas is drawn in from adjacent switchgear areas through louvers, filters, and grills. To make up for the battery room exhaust and to provide ventilation air in the switchgear areas, independent supply ducts with an axial fan rated at 1500 cfm, electric heating coils, and prefilters are provided.

The control room emergency ventilation filtration and pressurization system consists of two redundant emergency air filtration units. The emergency ventilation system operation is automatically initiated upon receipt of a Control Building Isolation (CBI) signal. The CBI signal will provide a signal to the Control Building inlet isolation valves to open if they are closed and provide a signal to the "A" Train Control Building Emergency Ventilation Fan Inlet Damper to open, which in turn will start the "A" train Control Room Emergency Ventilation system fan and open the "A" Train Control Building Emergency Ventilation Filter Air Return Damper. If, after 60 seconds, adequate flow has not been obtained in the outlet ductwork of the "A" train Control Room Emergency Ventilation system, the "B" Train Control Building Emergency Ventilation Fan Inlet Damper will receive a signal to open, which in turn will start the "B" train Control Room Emergency Ventilation fan and open the "B" Train Control Building Emergency Ventilation Filter Air Return Damper. This places the Control Room Emergency Ventilation system in the pressurized filtration mode of operation within two (2) minutes of receipt of a CBI signal. This provides a source of filtered outside air with which to pressurize the Control Room Envelope.

Each of the air conditioning units is supplied with chilled water by the control building chilled water system. The control building chilled water system is redundant and consists of two 100 percent capacity water chillers, two 100 percent capacity chilled water pumps, and two expansion tanks. Each chiller is rated at 250 tons of refrigeration. Each chilled water pump is rated at 450 gpm. The chilled water piping is arranged in two redundant flowpaths to serve the control building air conditioning unit cooling coils.

Each air conditioning unit cooling coil has a flow control valve controlled by a thermostat in the respective area. The differential pressure control valve automatically maintains constant return flow to the chilled water pump by modulating bypass flow in proportion to varying air conditioning system flow.

All Category I electrically-powered motors and controls associated with the control building air conditioning and ventilation systems and the chilled water systems are redundant to ensure operability of the control building air conditioning and ventilation as a result of a single failure of any component. In the event of a loss of power under either normal operating or accident conditions, emergency power is supplied from either the preferred off site source or the emergency diesel generators.

All outside air supply and exhaust ducts for the control room pressure envelope air conditioning system, kitchen-toilet exhaust system, and purge system are fitted with air-operated butterfly valves located as close as possible to the control building wall.

The control building is heated electrically. Area thermostats activate heating elements in the control room air conditioning units to maintain a minimum design temperature. A control switch activates heating elements in the instrument rack and computer room air conditioning units in the event heating is required. The mechanical equipment space is heated with electric unit heaters that are controlled separately from thermostats located in the room. The chiller equipment space is heated with electric duct heaters and electric unit heaters that are controlled separately from thermostats. Electric heaters are not required to function following loss of off site power.

The control building purge ventilation system removes smoke, carbon dioxide or Halon from the instrument rack and computer rooms, the switchgear rooms, and the mechanical equipment room through administrative controls. The system is designed to permit the operator to purge each space containing smoke, carbon dioxide or Halon by opening the supply and exhaust purge isolation dampers from outside that space.

To eliminate the cable spreading area purge duct as a potential path for carbon dioxide to migrate into the control room or switchgear rooms, the cable spreading area portion of the purge system has been blanked off and retired in place. Portable fans will be used to remove carbon dioxide, smoke, or Halon from the cable spreading area and control room.

9.4.1.3 Safety Evaluation

The control building air conditioning, emergency ventilation filtration, and chilled water systems are Seismic Category I and QA Category I. Ventilation, except for the kitchen-toilet exhaust and the purge system, are Seismic Category I and QA Category I. All of the systems are enclosed in a Category I missile- and tornado-protected building.

A radiation monitor connected with the makeup air duct of the control room area air conditioning units detects and respond to the presence of radioactivity. At the discretion of the operator, the emergency ventilation system can be started manually and the return air of the control room or the outdoor air supply diverted through the emergency ventilation filtration assembly.

High radiation detected by the monitors located in the air intakes result in a control building isolation (CBI) signal (Section 6.4).

During control building isolation, the Control Room Emergency Ventilation (CREV) system is automatically started in the pressurized filtration mode to provide filtered outside air to pressurize the control room.

Fusible link fire dampers are provided on openings in fire barriers separating fire areas. The dampers automatically isolate the area affected by fire. Fire damper assemblies installed in ventilation ductwork common to redundant portions of this system consist of at least two fire dampers in parallel in order to preclude a single failure of one fire damper from impairing the safety function of the system. Administrative controls to shut down control room air conditioning units in the event of a fire detection alarm within the control room envelope are used to ensure fire damper closure if a fire exists. Tightly sealed doors, sealed penetrations and fire walls inhibit smoke, heat, carbon dioxide or Halon from entering the control room. A purge system is provided to remove smoke or gases from the instrument rack and computer rooms, switchgear rooms and the mechanical equipment room. The control room proper and cable spreading area are purged manually by portable fans. The chiller room has 100 percent outside air circulation. Based on double damper isolation, potential smoke or CO_2 leakage into the control room from areas serviced by the purge system is limited. The purge system shares a common air intake duct, but is operated completely independent of all control building air conditioning and ventilation systems. The largest area served by the purge system can be ventilated at a rate of approximately one air change per hour.

9.4.1.4 Inspection and Testing Requirements

The control building air conditioning and ventilation system was field tested and inspected for air balance and completeness of installation.

The control room emergency filter ventilation system is tested in accordance with the guidance outlined in Regulatory Guide 1.52, Revision 2, as discussed in Table 1.8-1.

All control building air conditioning and ventilation systems not normally in use (standby) are operationally tested once per quarter (see Test 1 and 3 below), with the exception of the control room emergency ventilation system which is on a staggered monthly test basis (see Test 3 below). The control building isolation signal is operationally tested at intervals not greater than once per refueling (see Test 2 below), or at major alteration of the control room envelope pressure boundary.

The system tests are conducted as follows:

Test (1): Simulate a component failure in a train of the control building air conditioning system.

Result: The failure causes a complete changeover to the standby control building water chiller, chilled water system, and air conditioning units serving the control room area and the instrument rack and computer room.

Test (2): Simulate a control building isolation (CBI) signal to control building ventilation makeup air dampers.

Result: The signal automatically closes the control building ventilation makeup air dampers.

Test (3): Simulate a component failure in any control building chiller equipment space ventilation or emergency ventilation filtration subsystem.

Result: The component failure causes a changeover to start a redundant fan.

All control building air conditioning and ventilation unit components except for switchgear room backup units are tested, at intervals not exceeding once per refueling, as follows:

> air conditioning units, supply fans, exhaust fans, water chillers, and pumps are started and functionally checked. An acceptable level of performance for air conditioning units and supply and exhaust fans is that they start and reach their operating speed (as indicated by no low flow alarms present). An acceptable level of performance for a water chiller is that it starts and operates for a length of time to indicate that normal pressures and temperatures have been reached. An acceptable level of performance for the chilled water pump is that it starts and reaches its operating speed with full flow through the pump.
>
> All tests are considered satisfactory if the ventilation panel and visual observations indicate that all systems and components have operated as designed.

System operability is assured by the surveillance requirements imposed by Technical Specifications. Additional component inspections and planned maintenance is performed periodically in accordance with industry practice to maintain optimum system performance.

The testing and inspection of the control room pressurization system is described in Section 6.4.5.

9.4.1.5 Instrumentation Requirements

The control building air conditioning units, except the east and west switchgear rooms air conditioning units, have a STOP-AUTO-START control switch and indicator lights on the main heating and ventilation panel in the control room. Each air conditioning Train (A and B) has a NORM-TEST selector switch.

With the selector switch in NORM and the air conditioning units' control switch in AUTO, the air conditioning units are started and stopped automatically when the associated chilled water pump is started or stopped. The air conditioning units are controlled manually when the selector switch is in TEST.

The east and west switchgear rooms each have an air conditioning unit that is normally running and a backup air conditioning unit that is started and stopped automatically by an area temperature switch.

Chilled water is supplied to the east and west switchgear air conditioning units by the running chilled water train. Chilled water isolation valves in each Train (A and B) are interlocked to open and close respectively when the associated chilled water pump is started and stopped.

Control switches and indicator lights for the chilled water isolation valves and the east and west switchgear rooms air conditioning units are on the main heating and ventilation panel in the control room.

Temperature control valves for the normally running east and west switchgear room air conditioning units are modulated by temperature controllers. The backup air conditioning units have temperature control valves interlocked to open when the area temperature is high and close when the air temperature is low.

The chilled water pumps are provided with control switches and indicator lights locally near the equipment, at the switchgear, and at the main heating and ventilation panel. REMOTE/LOCAL control switches are located at the switchgear. When local control is selected, an annunciator is activated on the main control board.

One chilled water pump is normally running with the other pump on standby. The standby pump is started automatically by a low air flow signal from air conditioning units in the running Train (A and B), or if the running chiller's outlet chilled water temperature is high, or if the running chilled water pump flow is low. Starting the standby chilled water pump causes a complete change over of air conditioning trains. The train that was running is shut down and the standby train is started.

In normal operation, the chilled water pumps are not affected by a CBI signal. The CBI signal prevents the running pump from being manually stopped from the control room.

The chillers are provided with ON-STOP chiller safety circuit push buttons and START-STOP pushbuttons for local manual control. The chiller safety circuit is normally ON for both chillers. The chillers are started automatically when the associated chilled water pump is started.

Control room air conditioning unit heaters are controlled by automatic temperature controllers. Instrument rack and computer room air conditioning units are controlled by temperature switches in the event heating is required.

The control room envelope area is automatically pressurized by the Control Room Emergency Ventilation system after a CBI signal is initiated.

A CBI signal is initiated when any of the following conditions exist:

- air-intake radiation high;
- containment pressure high 2 out of 3 signal;
- manual initiation from main control board;
- manual initiation from main heating and ventilation; or
- manual safety injection signal.

The control building ventilation makeup dampers and the control building isolation valves have control switches and indicator lights on the main heating and ventilation panel. Engineered safety features status lights on the main control board indicate when the valves and dampers are closed. The opened and closed positions are monitored by the plant computer. The control building air makeup dampers and isolation valves are automatically closed on receipt of a CBI signal.

The chiller equipment space supply fans have control switches and indicator lights on the main heating and ventilation panel. The exhaust fans are interlocked to start and stop with the associated supply fan. One train is normally running with the other train on standby.

The purge supply fan is interlocked with the purge supply damper. The supply fan is started when the supply damper is opened and stopped when the damper is closed. The purge exhaust fan is manually started from a control switch at VP1. A control switch and indicator lights for the fans and damper are located on the main heating and ventilation panel.

Control switches and indicator lights for manual control of the east and west switchgear supply fans and the battery room exhaust fans are located on the main heating and ventilation panel in the control room. The battery exhaust fans are interlocked to start and stop respectively when the associated switchgear supply fan is started and stopped.

The following instrumentation and controls are located on the main heating and ventilation panel.

Annunciators:

- trouble alarm for each air conditioning unit;
- chiller equipment space supply fan system trouble;
- battery room hydrogen high;
- control building emergency ventilation fan system trouble;
- control room area temperature high;
- filter differential pressure high;
- expansion tank chilled water level;
- chilled water system A or B trouble;
- chilled water pump A or B flow low;
- service water pump A or B flow low;
- air flow battery rooms 1, 3, and 5; and
- air flow battery rooms 2 and 4.

Indicators:

- differential pressure between west control room stairway and control room;
- hydrogen level for each battery room;
- pressure for air pressurization system; and
- air storage tank reduced pressure.

The following instrumentation and controls are located on the main control board.

Annunciators:

- any motor control center power not available;
- control building isolation signal bypass Train A and bypass Train B;
- fire - control building inlet ventilation smoke; and

Power not available status lights are provided on the rear of the main control board for each motor control center.

All radiation monitor alarms annunciate in the control room.

9.4.2 FUEL BUILDING VENTILATION SYSTEM

The fuel building ventilation system (Figure 9.4–2) removes heat generated by equipment and water vapor from fuel pool evaporation, prevents moisture condensation on interior walls, provides a suitable environment for equipment operation and personnel. It also limits potential radioactive release to the atmosphere during normal operation or anticipated operational transients. This system is not credited in the fuel handling accident analysis (Section 15.7.4).

9.4.2.1 Design Bases

The fuel building ventilation system is designed in accordance with the following criteria.

1. General Design Criterion 2, as related to the system being capable of withstanding the effects of earthquakes.

2. General Design Criterion 5, as related to shared systems and components important to safety.

3. General Design Criterion 60 and Regulatory Guides 1.52 and 1.140, for design testing and maintenance criteria for atmosphere cleanup systems.

4. General Design Criterion 61 and Regulatory Guide 1.13, for fuel storage and radioactive control.

5. Outdoor air design temperatures are listed under design weather data in Section 9.4. The fuel building ventilation system is designed to maintain the d. following space temperatures during normal operation.

Spent Fuel Pool Area	Maximum Space Temperature	Minimum Space Temperature
a. Pool water temperature is greater than 140°F	98°F	85°F
b. Pool water temperature is greater than 100°F	95°F	85°F
c. Pool water temperature is less than 100°F	95°F	65°F
d. All other areas	104°F	65°F

6. Air flow is directed from areas of lower potential radioactivity to areas of higher potential radioactivity.

7. The fuel building exhaust ventilation system components are located in the auxiliary building, a seismic- and tornado-protected structure. This system is capable of withstanding the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, internally generated missiles, pipe whip, and jet impingement forces associated with pipe breaks, in accordance with General Design Criteria 2 and 4.

8. Radiation detectors are located in the fuel building ventilation system to monitor airborne effluent activity during normal operation, for anticipated operational transients, and following postulated accidents. Section 11.5 gives the details of the process and effluent radiological monitoring system.

9.4.2.2 System Description

The fuel building ventilation system includes a nonnuclear safety related supply air system, exhaust air system, and a nonnuclear safety related portion of the exhaust air system. Principal component design and performance characteristics are listed in Table 9.4–3.

The supply air system consists of three 50 percent capacity heating and ventilating units shared between the waste disposal building ventilation system and the fuel building ventilation system. Each heating and ventilating unit consists of the following components described in the order of air flow travel:

1. prefilter

2. hot water preheat coil

3. hot water reheat coil

4. fan

The prefilter is an extended dry media type with rigid frame.

The hot water preheat coil is capable of raising the incoming outside air temperature from 0°F to 50°F.

The hot water reheat coil raises the incoming air from the preheat coil to maintain winter design temperature of 65°F.

Heating of the building is provided by the heating and ventilating units. The ventilation system supplies air to the spent fuel pool area and remaining portions of the building. A reheater, supplied from the hot water heating system, serves the spent fuel pool area to maintain an indoor temperature of 85°F during winter when the outside air temperature is between 0°F and 50°F and the spent fuel pool water temperature is greater than 100°F. This design maintains the walls and ceiling surface temperatures in this area above the inside air dew point, minimizing condensation.

Heating of the building during periods of plant shutdown is provided by hot water unit heaters.

The supply air system provides approximately 39,000 cfm during normal operation. The supply air flow is controlled by an air-operated damper mounted in the supply ductwork to the fuel building. Two safety related wall mounted backdraft dampers located on the east wall of the fuel building provide makeup air to the building in the event of loss of the non safety related supply air system or the isolation of the same system following a failure of one of the two redundant special filter assemblies.

The exhaust portion of the system consists of redundant 100 percent capacity special filter assemblies with associated fans and dampers and one nonnuclear safety related 100 percent capacity exhaust fan. The normal exhaust system provides approximately 41,360 cfm during normal plant operation, while the exhaust system maintains the building at slightly negative pressure if operating during fuel handling operation and accident conditions in relation to the above supply air quantities. The fuel building ventilation exhaust system serves all areas of the fuel building and is discharged (unfiltered or filtered) through the radiation monitored ventilation vent.

The flow of the air within the fuel building is directed from areas of low potential for airborne contamination to areas of greater potential for airborne contamination. The unfiltered exhaust air, not subjected to contamination under normal operation conditions, is discharged through the monitored ventilation vent. (See Section 9.4.2).

The fuel building ventilation exhaust system is capable of detecting and controlling radioactive contamination. On receipt of a high radioactivity signal from the particulate and gas monitor which samples the ductwork exhaust, the unfiltered ventilation exhaust system is manually isolated, in the control room, by the closing of two safety related dampers located on the supply and exhaust sides of the unfiltered exhaust fan as shown on Figure 9.4–2. In addition, supply air is provided at reduced capacity by this manual actuation, and verifying and locking in the field of a nonnuclear safety related damper in the supply ductwork, then the exhaust air is manually diverted through one of the two fuel building filtration units. Operational control of the supply air assures the prevention of condensation of water vapor from the spent fuel pool and maintenance of a negative pressure in the fuel building to prevent uncontrolled release of radioactive contamination.

In the event of a failure in the nonnuclear safety related supply air system, the safety related backdraft dampers, which are mounted in the fuel building exterior wall, admit the required makeup air.

During fuel handling or movement of any loads within the spent fuel pool, the exhaust air may be manually diverted through one of the fuel building filtration units, in addition to reducing the supply air, thus maintaining a negative pressure.

9.4.2.3 Safety Evaluation

During normal plant operations, the ventilation air is discharged by one nonnuclear safety related exhaust fan to the atmosphere via the ventilation vent. A particulate and gas radiation monitor is provided which samples the exhaust air stream prior to the filtration units as discussed in Section 11.5. On receipt of a high radiation alarm, the exhaust air is manually diverted through one of the fuel building filtration units, the normal exhaust fan is stopped, and the associated safety related fan is started. High radiation signals from radiation monitors located above the spent fuel pool and in the new fuel storage area alarm locally and in the control room.

A single nonnuclear safety related damper with associated locking device is provided in the ventilation supply system to reduce air capacity in the fuel building so that a negative pressure can be maintained in the fuel building. The actuation of this damper occurs simultaneously with the filtration unit used to ensure maintenance of a negative pressure within the building. In the event of a failure in the nonnuclear safety related supply system, the safety related wall-mounted backdraft dampers admit the required makeup air. This operation prevents potentially contaminated air from leaving the spent fuel pool area. The filtered exhaust system is provided with redundant 100 percent capacity fans, dampers, and filtration units.

The fuel building ventilation exhaust system used during the emergency filtration modes is Seismic Category I, and is designed so that failure of a portion of the system does not compromise the operability of another portion.

A Category I air operated isolation damper is installed in the supply ductwork to the fuel building. The damper is interlocked with both exhaust filter trains to close upon failure of either train if both filters are running. Presently, dual filter train operation is not required nor included in plant operating procedures. Additional testing may be performed in the future to allow for dual train operation, if required. The three air handling units are isolated from each other by manually operated isolation dampers.

During refueling, one air handling unit operates and can be isolated from the other air handling units by closing a manual damper. This ensures against pressurization of the fuel building as a result of any single failure.

All ventilation exhaust ductwork is seismically supported. Ventilation supply ductwork located above the spent fuel pool and portions that compromise the integrity of safety related systems are also seismically supported. The ventilation exhaust system components, excluding the unfiltered air exhaust fan, are Seismic Category I. The modulating damper in the ventilation supply system to the fuel building is QA Category II and Seismic Category II. The wall mounted backdraft dampers are QA Category I and Seismic Category I. The isolation damper in the ventilation supply system to the fuel building is QA Category I and seismically supported. These categories are discussed in Section 3.2.

A standby redundant fuel building ventilation exhaust system is provided to assure that a loss of functional performance capability of the system does not occur due to a single active failure. Upon low flow in the operating exhaust fan discharge line, the standby system is automatically started and the isolation damper is automatically closed as discussed in Sections 7.3.2 and 9.4.1.5.

Fire damper assemblies installed in ventilation ductwork common to redundant portions of this system consist of at least two fire dampers in parallel in order to preclude a single failure of one fire damper from impairing the safety function of the system.

In the event that the fuel building exhaust and filtration system is not in use, or the fuel building doors are not closed, suitable radiological monitoring shall be performed to ensure that the requirements of the Millstone Effluent Control Program are met.

In the event of a fuel handling accident in the fuel building, the Control Room personnel should take action to close the fuel building doors as soon as practicable and may choose to actuate the fuel building exhaust and filtration system. It should be noted that this system is not credited for post-accident mitigation of a fuel handling accident as described in Section 15.7.4.

9.4.2.4 Tests and Inspections

Test and inspections are not required for the fuel building ventilation system.

9.4.2.5 Instrumentation Requirements

A temperature controller mounted in the spent fuel pool area supply ductwork maintains the spent fuel pool area temperature at 85°F by modulating the hot water temperature control valve for the inlet air hot water heater, provided outside air temperature is less than 50°F (measured inside) and spent fuel pool temperature is higher than 100°F. When any one of the above two conditions is not present, the hot water temperature control valve is closed. The control circuit of the valve can also be activated manually with a normal and override control switch mounted on the local control panel.

The fuel building normal exhaust fan has a control switch and indicator lights on the main heating and ventilation panel in the control room. The normal exhaust fan starts automatically when any one of the fuel building supply fans is started, provided the normal exhaust fan inlet and outlet dampers are open.

The fuel building normal exhaust fan inlet and outlet dampers are manually operated from the main heating and ventilation panel in the control room, by control switches and indicator lights provided.

The fuel building air inlet damper has a MINIMUM POSITION/OPEN control switch with indicator lights on the main heating and ventilation panel in the control room.

The fuel building air inlet damper is interlocked with the normal exhaust fan as follows:

- full open when normal exhaust fan is running, and
- minimum flow position when the normal exhaust fan is not running.

Control switches and indicator lights are provided on the main heating and ventilation panel in the control room for manual operation of the fuel building filter bank exhaust fans and dampers. The exhaust fans are interlocked with the filter bank inlet and the fan discharge damper so that the two associated dampers must be open to run the fan.

Low airflow in a filter bank in service causes an automatic start of the standby filter bank.

The filter heater is controlled by a thermostat, provided the following interlocks are satisfied:

- associated exhaust fan running, and
- filter high air temperature cutout reset

Indicator lights on the main heating and ventilation panel in the control room indicate when a filter heater is energized or deenergized.

The following instrumentation is located on the main heating and ventilation panel in the control room.

Annunciators:

- fuel building filter system differential pressure high;
- fuel building Exhaust Fan A breaker auto trip/overcurrent;
- fuel building Exhaust Fan B breaker auto trip/overcurrent;
- fuel building Exhaust Fan A transfer switch in local position; and

- fuel building Exhaust Fan B transfer switch in local position.

The following parameters are monitored by the plant computer:

- fuel building filter exhaust fan motor overcurrent;
- fuel building filter exhaust fan auto trip;
- fuel building filter exhaust fan breaker position;
- differential pressure across moisture separator high;
- differential pressure across prefilter high;
- differential pressure across inlet HEPA filter high;
- differential pressure across charcoal filter high; and
- differential pressure across outlet HEPA filter high.

The following instrumentation and controls are located at the load center:

- local/remote control switches and indicator lights for the fuel building filter exhaust fans;
- control transfer switch for each fuel building filter exhaust fan; and
- position indicators for each fuel building filter inlet damper and exhaust fan discharge damper.

Local differential pressure indicators are provided for each fuel building filter section.

Relative humidity upstream of each charcoal filter is indicated locally.

9.4.3 AUXILIARY BUILDING VENTILATION SYSTEM

The auxiliary building ventilation system (ABVS) (Figure 9.4–2) provides an environment suitable for personnel access and equipment operation. It also controls and minimizes the potential for spread of airborne radioactive material within the building.

9.4.3.1 Design Bases

The design bases for the auxiliary building ventilation system are in accordance with the following:

1. General Design Criterion 2 for the auxiliary building to protect against natural phenomena (Chapters 2 and 3).

2. General Design Criterion 4 for the auxiliary building ventilation ducts and components to protect against adverse environmental conditions and missiles (Chapters 2 and 3).

3. General Design Criteria 60 and 64 for control and monitoring radioactivity releases in the auxiliary building ventilation system.

4. General Design Criterion 5 for shared systems and components important to safety.

5. Regulatory Guide 1.29 for the seismic design classification of system components.

6. Regulatory Guide 1.26 quality group classification of systems and components.

7. Regulatory Guide 1.52 for the air filtration and adsorption units (Section 1.8.1.52).

8. Branch Technical Positions ASB 3-1 and MEB 3-1 for breaks in high and moderate energy piping systems outside containment.

9. Branch Technical Position CMEB 9.5-1 for fire protection design.

10. Outdoor air design conditions are listed in FSAR Section 9.4.

11. Indoor air design temperature of 104°F in the summer and a minimum of 65°F in the winter except for the charging pump and reactor plant component cooling pump and heat exchanger area winter design temperature which is maintained above 32°F during an emergency bus single failure. The motor control center (MCC), rod control, and cable vault areas are maintained at 86°F during normal operation in the summer and not more than 120°F during DBA.

12. Typically air flow shall be maintained from the least contaminated to the more contaminated spaces.

13. The auxiliary building shall be maintained at negative pressure.

14. The ABVS is nonnuclear safety related with the exception of: the building isolation dampers; charging pump, component cooling water pump, and heat exchanger ventilation system; MCC, rod control, and cable vault ventilation system; and the auxiliary building filtration units including fans, dampers, and segment drainage up to and including the isolation valves, all of which are Safety Class 3.

15. The ABVS is actuated manually. The charging pump, component cooling water pump, and heat exchanger areas ventilation supply and exhaust dampers to and from each charging pump cubicle are actuated by the operation of the charging

pumps. The auxiliary building ventilation isolation dampers are actuated by safeguards actuation signals.

16. The ABVS normally maintains the charging pump cubicle temperature above the solubility temperature limit of 59°F for a 4 percent boron concentration except during an emergency bus single failure in the winter at which time the temperature is maintained above 32°F.

9.4.3.2 System Description

The ABVS is comprised of the following subsystems:

- auxiliary building general area ventilation;
- charging pump, reactor plant component cooling water pump, and heat exchanger areas ventilation;
- auxiliary building filtration system;
- MCC, rod control, and cable vault areas ventilation; and
- electric cable tunnel area ventilation.

The design parameters for the principal components of the ABVS are given in Table 9.4–4.

The general area ventilation air supply portion includes two 50 percent capacity air handling units, each rated at 33,000 cfm. (One of the units has been rebalanced to operate at 31,550 cfm). The air exhaust portion consists of two axial flow fans; one rated at 20,000 cfm (rebalanced to operate at 22,000 cfm) and the other rated at 50,000 cfm.

Each air handling unit includes a prefilter, preheat coil, fan, and heating coil. The coils use hot water as a heating medium. Outside air is supplied continuously to all levels of the auxiliary building through ductwork.

The exhaust fans maintain the building at a negative pressure. One exhaust fan draws air from elevation 66 feet 6 inches and elevation 43 feet 6 inches, and the other draws air from elevation 24 feet 6 inches and elevation 4 feet 6 inches plus two rooms at elevation 43 foot 6 inches and one area at elevation 66 foot 6 inches. The air flow path within the auxiliary building is from general areas with lesser potential for contamination to the cubicle area where a greater potential for contamination exists except during winter mode alignment. Exhaust registers are mainly located within the cubicle areas. Once air is drawn from the building space, it is either discharged to the atmosphere through the ventilation vent, diverted to the auxiliary building filtration units, prior to release through the ventilation vent or mixed with outside air to maintain a minimum air temperature.

The plant ventilation vent is the release point for all ventilation exhaust air from the auxiliary, waste disposal, and fuel buildings, the containment structure, and contaminated portions of the service building.

The ventilation vent effluent point of release is at elevation 157 feet and 133 feet above site grade level, and the discharge velocity is approximately 2,500 fpm. The vent is located in the northeast corner of the turbine building auxiliary bay roof. A radioactive particulate and gaseous detection system is installed in the common duct to monitor effluent and provide visible and audible alarm in the control room. Section 11.5 gives details of the process and effluent radiological monitoring systems. The total air flow through the ventilation vent is also measured and monitored by the RMS computer system.

Air samples are drawn from several points in the exhaust ductwork for radioactivity analysis upstream of the filtration units. High radioactivity initiates an alarm. Subsequent to an alarm signal, exhaust air is manually diverted through one of the two filter units. The filtration capacity per unit is 30,000 cfm. Each unit includes, in the direction of flow, a moisture separator, electric heating coil, prefilter, a high efficiency particulate air (HEPA) filter, a charcoal adsorber and a second HEPA filter. The prefilter has a minimum filtration efficiency of 80 percent as rated by ASHRAE Standard 52. A gasketless, nontray type charcoal adsorber is designed for a 0.22 second dwell time per 2 inch depth for gases at a flow velocity of 46 fpm. Four inch depth of charcoal is provided. The impregnated charcoal is capable of removing in excess of 99 percent of methyl iodide (CH I) and 99.5 percent of elemental iodine at nominal design air flow. Testing of used charcoal, post Generic Letter 98-02 (Ref. Amendment 184) uses ASTM D3803-89 testing standards assuring charcoal efficiency of 97.5% or greater. The HEPA filters have a minimum filter efficiency of 99.97 percent when filtering particulates that are 0.3 micron or larger. Section 6.5 discusses the filter design bases in detail. The auxiliary building radioactive particulate and gas detection system is described in Section 11.5.

The charging pump and reactor plant component cooling water pump and heat exchanger areas ventilation system has two modes of system operation with two season dependent system manual damper positions. The winter mode is established for the time period between November 1 and May 1. The summer mode is used for the remainder of the year. In the winter mode of operation, manual dampers are positioned such that outside air is mixed with return air at a fixed rate to maintain a minimum area temperature as defined in Section 9.4.2.1. Supplementary heat is provided by eight safety related electric heaters (four on each train) powered from emergency power buses. Air is supplied directly to the reactor plant component cooling water pump and heat exchanger area, then drawn into the charging pump cubicles through the door openings. Air not returned is exhausted from both areas directly to the Auxiliary Building roof vent and then to the Turbine Building stack. In the filtration mode of operation, air is exhausted through the Auxiliary Building Filtration Units then directed to the Auxiliary Building roof vent and ultimately released through the Turbine Building stack.

In the summer alignment, the system manual dampers are repositioned such that the recirculation flow path is isolated and outside air is supplied directly to both, the component cooling water pump area and the charging pump cubicles. An exhaust flow path remains the same as described for the winter mode of operation.

In the event of a SIS, the electrical tunnel area ventilation is shutdown and the building isolation dampers close. In the event of a SIS or a CDA, the auxiliary building general area ventilation is shutdown; the building outlet isolation dampers close; the charging pump, reactor plant component cooling water pump, and heat exchanger ventilation exhaust dampers close; the auxiliary building filter unit inlet and outlet dampers open; the filter exhaust fans start automatically and the charging pump, reactor plant component cooling water pump, and heat exchanger supply and exhaust fans continue to operate venting through the turbine building stack after filtration. This ABVS line-up augments SLCRS in drawing the required negative pressure in the secondary containment. The negative pressure aspects of ABVS are described in Section 6.2.3. In the event of a LOP signal, system alignment is identical to responses to SIS and CDA except that building inlet isolation dampers remain open and the auxiliary building filter unit inlet and outlet dampers open from the sequenced safeguards signal.

In addition to the ventilation systems described, the MCC, rod control and cable vault ventilation system serves the electrical equipment areas on elevation 24 feet 6 inches and elevation 43 feet 6 inches. Each of the redundant system supply units consists of a prefilter, service water cooling coil, chilled water cooling coil, and fan. Either unit continuously recirculates 26,000 cfm of conditioned air through the electrical spaces to maintain design temperature. During normal plant operation, cooling water is supplied to the MCC/Rod Control Area air-handling units by the Chilled Water system. In the event of a high return air temperature or a Loss of Power (LOP) signal, the service water system MCC and Rod Control area booster pumps will automatically start if the associated air conditioning unit is operating.

The electric cable tunnel area is ventilated by a 2,000 cfm capacity exhaust fan which discharges air to the ventilation vent. This same exhaust path and fan is also used to purge the two MCC and rod control areas utilizing two normally closed purge exhaust dampers. Supply air to the electric tunnel area is furnished from the service building ventilation system (Section 9.4.11).

9.4.3.3 Safety Evaluation

Radiation monitors are provided at various points in the exhaust air duct stream of the auxiliary building ventilating system. Upon the receipt of a high radiation signal, exhaust air can be manually diverted through one or both auxiliary building filtration units prior to its discharge to the ventilation vent. This reduces any potential of radioactive contaminated air being released to the atmosphere.

The charging pump, reactor plant component cooling water pump, and heat exchanger ventilation system; and the MCC, rod control, and cable vault ventilation system are nuclear safety related and are provided with redundant 100 percent capacity supply and exhaust fans.

All ductwork in the auxiliary building is seismically supported thus eliminating the possibility of the safety related equipment being damaged by ductwork. The charging pump, reactor plant component cooling water pump, and heat exchanger ventilation system; the MCC, rod control, and cable vault ventilation system; the filtration units including their fans, and building isolation dampers are QA and Seismic Category I.

9.4.3.4 Inspection and Testing Requirements

All auxiliary building ventilation subsystems are air-leak and pressure tested, air-balanced for supply and exhaust, and inspected for proper installation of ductwork, equipment, supports, etc.

All auxiliary building general area ventilation subsystems operate continuously during normal plant operation and no periodic testing is required. Routine maintenance and surveillance are performed as required.

9.4.3.5 Instrumentation Requirements

The auxiliary building ventilation supply units and exhaust fans have control switches and indicator lights on the main heating and ventilation panel in the control room. The exhaust fans are interlocked with the associated auxiliary building ventilation inlet dampers, filter inlet dampers and normal outlet dampers. The auxiliary building ventilation inlet dampers and either the filter inlet or the normal outlet dampers must be open for the exhaust fan to run. A temperature switch is used to monitor the supply unit preheating coil outlet temperature and stop the exhaust fan when temperature drops to 35°F or less. An annunciator is alarmed on the auxiliary building ventilation panel and an auxiliary building ventilation trouble annunciator is alarmed on the main heating and ventilation panel in the control room when inlet air temperature is 35°F or less.

The auxiliary building air supply units are interlocked with the associated exhaust fans. The exhaust fan must be running to operate the associated air supply units.

Exhaust air from the charging pumps and component cooling water and heat exchanger areas is monitored by temperature elements which alarm in the control room on low and high building temperature.

Exhaust air is monitored by radiation monitors and high radiation is alarmed locally and in the control room. Air flow is monitored by the RMS computer system; indication is available through the RMS computer system workstations.

Engineered safety feature status lights on the main control board indicate the status of the outlet and inlet dampers of the auxiliary building ventilation system. The outlet dampers are closed automatically on receipt of a SIS, CDA, or loss of power (LOP) signal. The inlet dampers are closed automatically on receipt of a SIS signal.

The MCC, rod control, and cable vault air conditioning air supply units have control switches and indicator lights located on the main heating and ventilation panel in the control room. One air conditioning unit is normally running serving both MCC and rod control train areas while the other unit is on standby. On receipt of a carbon dioxide (CO_2) discharge signal into either train area, the automatic closure of fire dampers in the interconnecting ducts between the two air conditioning units isolates the two MCC and rod control areas from each other. The automatic startup of the standby unit via low airflow switch actuation in the suction and/or discharge cross-connect lines allows each air conditioning unit to serve its own train area.

The electric tunnel area exhaust fan has a control switch and indicator lights on the main heating and ventilation panel in the control room. The exhaust fan is automatically stopped when the exhaust fan outlet dampers close on receipt of a SIS. On receipt of a CO_2 discharge signal to either electric tunnel area, the exhaust fan is automatically stopped and the associated electric tunnel exhaust damper is closed. On receipt of a CO_2 discharge signal into either MCC and rod control area, the exhaust fan is automatically stopped and both MCC and rod control area purge exhaust dampers are closed. Engineered safety feature status lights on the main control board indicate when the dampers are closed.

9.4.4 TURBINE BUILDING AREA VENTILATION SYSTEM

The turbine building area ventilation system, a nonnuclear safety related system, removes the heat dissipated from equipment, piping, and lighting to provide a comfortable environment for personnel and proper function of equipment, instrumentation, and control.

9.4.4.1 Design Bases

The turbine building area ventilation design is based on the following criteria:

1. During the summer, coincident with the outdoor air design temperature, the turbine building temperatures range from 95°F at operating floor to 104°F just below the roof. During the winter, the inside temperature is maintained at a minimum of 65°F.

2. The system is non safety related and is designated nonnuclear safety class (NNS).

3. Branch Technical Position ASB 9.5-1, Fire Protection for Nuclear Power Plants.

9.4.4.2 System Description

The turbine building area ventilation system is designed as shown on Figure 9.4–3. The principal components and approximate parameters are listed in Table 9.4–5.

The supply portion of the system consists of four axial flow fans, each with inlet sound attenuators, mixing plenum, associated ductwork, and air intake louvers and dampers. There are also six transfer fans, which transfer air from the lower level and battery room to the upper level of the turbine building.

The exhaust portion of the system consists of twelve axial flow exhaust fans located below the turbine building roof. Each fan has sound attenuators, ductwork, backdraft damper, and a weatherproof hood.

The storage area, condensate polishing area, elevator machinery room, lubricating oil storage room, and sample sink areas have separate ventilation systems.

The turbine building supply and transfer fans are manually started. Three exhaust fans are interlocked electrically with each supply fan's outside air damper. As an outdoor inlet damper opens, the interlocked exhaust fans start up in sequence according to the damper position switches. As the damper closes, the exhaust fans shut down accordingly. The direction of the air flow inside the building is from the respective floor level to the inlet of exhaust fans under the roof.

Each supply fan is rated at 165,000 cfm and takes suction from duct plenums located on the east wall of the turbine building at the operating level.

The suction portion of each supply fan ductwork is arranged to mix the outside air and recirculated air, when necessary, to temper the outside air. The supply fan discharge air is distributed through ductwork to all levels of the turbine building. The temperature of the turbine building ventilation system supply air is maintained at a minimum of 65°F during the winter.

There are six turbine building ventilation transfer fans, each rated at 70,000 cfm. Four fans are located near the west wall, and the other two are located near the east wall. These fans transfer air from lower levels to the turbine building operating level in the direction of the turbine building exhaust fans. The transfer fans provide a better mixing of air and create a more uniform temperature inside the building.

Four sets of exhaust fans, each containing three fans rated at 60,000 cfm each, are interlocked with the four supply fan outside air dampers. As an inlet air damper opens, a set of three exhaust fans is energized in sequence by the damper position switches mounted such that, when the outside air damper is 35 percent open, the first exhaust fan runs; at 70 percent open, the second exhaust fan runs; and at 100 percent open, the third fan runs. As the outside air damper closes, the fans shut down accordingly.

Separate ventilation systems are provided for each of the following areas:

1. The two turbine building lubricating oil storage rooms are ventilated by separate systems, each consisting of a 2,000 cfm exhaust fan. Each lubricating oil storage room is ventilated by turbine building air which enters the room through a fire-damper opening in the wall. The exhaust fan takes its suction through a fire-dampered opening in the wall from the lubricating oil storage room and exhausts the air at the turbine building roof through a weatherproof hood.

2. Battery room 6 is ventilated by a 1200 cfm supply fan mounted on the battery room roof. The fan takes suction from the relatively cool ambient air in the Turbine Building basement area. The supply fan is controlled locally at the entrance to the battery room. The inlet and outlet ducts are equipped with fire dampers. The concentration of the hydrogen in battery room number 6 is continuously monitored with indication on the ventilation panel VP-3.

3. The elevator machinery room is ventilated by exhausting 500 cfm of air with a propeller roof exhaust fan.

4. The sample sink area ventilation system consists of a sample hood, prefilter, high efficiency particulate air (HEPA) filter, and a 1,700 cfm centrifugal exhaust fan. Air is drawn through the hood over the sample sink, through the filters, and discharged into the turbine building.

5. The welding area ventilation system consists of a manually operated 5,900 cfm axial exhaust fan, sound attenuator, back draft damper, and weatherproof exhaust hood. The 5,900 cfm is supplied to the area by infiltration. The entrance door to this area is normally closed, having no interlock with the exhaust fan.

6. The maintenance/operations offices are supplied by a 10,000 cfm air conditioning package unit. This unit is located in the turbine and laydown storage area, and is manually started with an indicator.

7. The maintenance toilet area is ventilated by a 450 cfm exhaust fan mounted on the outside wall. The ventilation air enters the maintenance toilet area through a louvered door from the turbine area.

8. The condensate polishing area is ventilated by one supply fan and one exhaust fan, each rated at 10,400 cfm. The condensate polishing area supply fan supplies outside air throughout the condensate polishing area through the ductwork. This fan has its own weatherproof hood. The exhaust fan discharges air to the atmosphere through a sound attenuator and weatherproof hood.

Hot water unit heaters, provided inside the turbine building, maintain the minimum 65°F temperature in the winter season.

9.4.4.3 Safety Evaluation

The turbine building ventilation system does not have safety related functions, and its failure does not affect operation of any other safety related system or component.

9.4.4.4 Inspection and Testing Requirements

The turbine building ventilation system was air-leak tested, pressure tested, air balanced for supply and exhaust, and inspected for proper installation of ductwork, insulation, equipment, and supports. Periodic testing, corrective and preventive maintenance are performed to keep the systems running properly.

9.4.4.5 Instrumentation Requirements

The turbine building ventilation system operating parameters are monitored, indicated, and controlled, locally or remotely, as follows:

The controls for the turbine building area ventilation system are located on the local ventilation panel in the turbine building. STOP-START control switches with indicating lights are provided for the turbine plant supply fans. Indicating lights are also provided on the load center for the supply fan.

ON-OFF control switches with indicating lights are provided for the following:

1. Sample sink exhaust fan
2. Turbine building transfer fan
3. Condensate polishing area supply fan
4. Welding area exhaust fan
5. Lube oil room exhaust fan
6. Turbine building exhaust fans
7. Maintenance area toilet exhaust fan
8. Maintenance/Operations office package air conditioning unit

First-out annunciators are provided on the turbine building area local ventilation system panel for an automatic trip or overcurrent trip of the turbine plant supply fans and also for a high hydrogen level in battery room number 6.

Indicators are provided on the turbine building area ventilation panel to monitor the following:

1. Turbine building supply fan discharge temperature
2. Turbine building supply fan AUTO TRIP (light only)
3. Battery room number 6 hydrogen concentration

The sample sink hood exhaust fan is controlled locally near the sample sink by an ON-OFF control switch with indicating lights.

An annunciator is provided on the main heating and ventilation panel in the control room for turbine plant ventilation trouble, which is actuated by an automatic trip or overcurrent in a turbine building area ventilation supply fan.

Computer inputs are provided for the turbine building supply fan breaker position.

9.4.5 ENGINEERED SAFETY FEATURES BUILDING VENTILATION SYSTEM

The function of the engineered safety features (ESF) building ventilation system (Figure 9.4–4) is to provide a suitable environment for personnel and equipment operation and to prevent or minimize the spread or release of airborne radioactive material to the atmosphere. Portions of the system are safety related.

9.4.5.1 Design Bases

The design bases of the ESF building ventilation system are:

1. The outdoor air design temperatures are listed in Section 9.4.

2. The ESFB areas are maintained at a temperature below 104°F. During winter, the indoor temperature is maintained at a minimum of 50°F.

3. To minimize the release of airborne radioactivity during a postulated accident, the ESFB areas adjacent to the containment are maintained at a negative pressure by exhausting air and diverting it through the supplementary leak collection and release system (SLCRS) filters (Section 6.2.3).

4. General Design Criterion 2, for structures housing the system and the system itself being able to withstand the effects of natural phenomena including earthquakes, tornadoes, hurricanes, and floods, as established in Chapters 2 and 3.

5. General Design Criterion 4, for structures housing the system and the system itself being able to withstand the effects of external missiles and internally generated missiles, pipe whip and jet impingement forces associated with pipe breaks.

6. Nuclear safety related areas are in accord with General Design Criterion 5, for shared systems and components important to safety. No systems or components are shared. A single active failure cannot result in the loss of system function performance capabilities.

7. Regulatory Guide 1.26, for the quality group classification of system components.

8. Regulatory Guide 1.29, for the seismic design classification of system components.

9. In accordance with Regulatory Guide 1.89, as described in IEEE 323-1974 for the environmental qualification of Class IE electrical equipment.

9.4.5.2 System Design

The ESF building ventilation system is shown on Figure 9.4–4 and the principal component design and performance characteristics are given in Tables 9.4–6 and 9.4–7. The ESF building ventilation system consists of two systems: normal and emergency ventilation.

The normal ventilation system is non safety related and consists of three sets of supply and exhaust fans and one self contained air conditioning unit. One set (SUPPLY 3HVQ-FN3, EXHAUST 3HVQ-FN4) serves the ventilation mechanical rooms, the second (SUPPLY 3HVQ-FN1, EXHAUST 3HVQ-FN2) serves the following areas:

1. Safety injection pump and quench spray pump areas, and residual heat removal pump and heat exchanger areas

2. Containment recirculation pump and cooler areas

3. Refueling water recirculation pump area

4. Motor-driven auxiliary feedwater pump areas

5. Turbine-driven auxiliary feedwater pump area; and

the third set of fans (SUPPLY 3HVQ-FN8, EXHAUST 3HVQ-FN7) ventilate the piping cubicles (RSS and QSS area) to provide air exchange during occupancy.

The MSS Valve Pipe Ventilation system (3HVQ-ACU3) consists of an 1300 cfm direct expansion, self contained air conditioning unit. The air conditioning unit consists of a centrifugal flow fan, direct expansion coil, filter, refrigerant tubing and a remote air-cooled condensing/ compressor unit (3HVQ-CND1). This system cools the MSS valve pipe tunnel when the temperature exceeds 90°F.

The normal ventilation system is designed to limit the temperature to a maximum of 104°F. Electric unit heaters keep all areas at a minimum temperature of 50°F during normal plant operation.

Except for exhaust from the ventilation mechanical rooms, ESF building normal ventilation system exhaust is monitored for radiation releases during normal plant operation.

The ESF building emergency ventilation system contains the following five safety related ventilation subsystems.

Two - Residual heat exchanger area, residual heat removal pump area, safety injection and quench spray pump area systems served by self contained air conditioning units (3HVQ*ACUS1A/1B).

Two - Containment recirculation pump and cooler area systems served by self contained air conditioning units (3HVQ*ACUS2A/2B).

One - Mechanical room and auxiliary feedwater pump areas system served by supply (3HVQ*FN5A/5B) and exhaust fans (3HVQ*FN6A/6B).

These subsystems are classified QA Category I and Seismic Category I, and are supplied with Class IE electric power. The self contained air conditioning units consist of a centrifugal flow fan, direct expansion coil, compressor, ASME III condenser, ASME III regulating valve and prefilter.

Each subsystem is designed to limit the temperature to a maximum of 104°F. The self contained air conditioning units start automatically whenever any of the safety related pumps within their respective area start, supply air throughout the equipment area and return the air to the units.

The safety related ventilation subsystem servicing the mechanical rooms and auxiliary feedwater pumps area consists of two redundant trains of 100 percent capacity axial flow supply fans (3HVQ*FN5A/5B) and exhaust fans (3HVQ*FN6A/6B). Design of this system permits the use of an outside air supply during the summer and air recirculation during the winter. A single train is capable of maintaining a maximum temperature at ≤ 104°F during the summer and a minimum of 50°F during the winter. The exhaust fan *FN6A/6B is interlocked with the supply fan *FN5A/5B. The supply fan can be manually started from the Main Control Room HVAC Panel VP1 or will start automatically under the following conditions.

a. Fan 3HVQ*FN5A will start on any of the following: (1) either 3HVQ*ACUS1A or ACUS2A starts, (2) the train “A” motor-driven Auxiliary Feed Water (AFW) pump starts.

b. Fan 3HVQ*FN5B will start on any of the following signals: (1) either 3HVQ*ACUS1B or ACUS2B starts, (2) the train “B” motor-driven Auxiliary Feed Water (AFW) pump starts.

c. When any of the three air-operated isolation valves to the Turbine Driven AFW pump opens, both trains “A” & “B” receive a start signal.

d. Whenever both Trains “A” & “B” receive a start signal, the following occurs:

    1. With neither trains in operation, train “A” (*FN5A) starts as the preferred/ lead train because train “B” (*FN5B) start circuit has a time delay.

    2. With a train in operation, and its low flow switch (*FS53) satisfied, it will prevent the second train from starting.

    3. If the low flow switch (*FS53) in the operating train senses a low flow, the second train will start.

Upon receipt of SIS, the dampers within the normal ventilation system close, isolating the safety injection pump, quench spray pump, RHR pump, and heat exchanger areas. At this time, the SLCRS (Section 6.2.3) starts and maintains a negative pressure within the interior cubicles. The safety related air conditioning units start and cool their respective areas.

9.4.5.3 Safety Evaluation

The ESF building normal ventilation system is not required to operate during or after a postulated accident and is not safety related. The failure of this nonessential system does not preclude operation of any essential safety related systems.

The ESF building emergency ventilation system is safety related and is required to operate during or after a postulated accident.

All of the safety related ESF building ventilation subsystems are located in a Seismic Category I structure that is tornado, missile, and flood protected. The redundant components are connected to redundant Class 1E buses and can function as required in the event of loss of off site power. The safety related ESF building ventilation system can withstand a single active component failure or failure of one of its Class 1E electric power sources without degrading the performance of the safety function.

The safety related ESF building ventilation system uses equipment of proven design. All components are specified to provide maximum safety and reliability. Consequences of probable component failures are tabulated in Table 9.4–7.

Each of the redundant safety injection and quench spray pump areas, residual heat removal pump and heat exchanger areas, and the containment recirculation pump and cooler areas has its own ventilation system. The redundant ventilation system ensures that, in the event of a ventilation unit failure, a second train is available. The auxiliary feedwater pumps and mechanical room areas have ventilation systems with two trains of 100 percent capacity supply and exhaust fans with common supply and exhaust ductwork. Fire damper assemblies installed in ventilation ductwork common to redundant portions of this system consist of at least two fire dampers in parallel in order to preclude a single failure of one fire damper from impairing the safety function of the system. These redundant fans ensure the integrity of this duct system.

During normal plant operation, safety related systems do not operate.

During plant shutdown, whenever a safety injection pump, a quench spray pump, or a residual heat removal pump is required to be operable, the corresponding safety related ventilation system is required to be operable. The safety related ventilation system is designed to automatically start whenever one of the corresponding pumps is started.

During a postulated accident, the ESF building emergency ventilation subsystems automatically start whenever any of their respective safety related pumps start. These ventilation systems supply and exhaust air throughout their equipment areas to maintain environmental conditions at which the pumps and coolers can perform their safety functions. Upon a failure of any of the safety related units in one train, the redundant train can maintain the areas at the designed conditions.

All areas in which safety related equipment is located are monitored for high temperature and annunciated in the control room. Upon a high temperature alarm within one of the areas the operator can switch to the redundant system for backup. Upon receipt of a safety injection signal, the residual heat removal pump and heat exchanger areas, safety injection and quench spray pump areas, and containment recirculation pump and cooler areas are isolated from the normal ESF building ventilation system. Two automatically-actuated dampers in series are provided to ensure isolation in each duct penetrating the interior cubicle walls. The SLCRS then exhausts air to maintain a negative pressure within these areas (Section 6.2.3).

9.4.5.4 Inspection and Testing Requirements

The ESF building ventilation systems were air-leak tested, pressure tested, air balance tested, adjusted, and inspected for proper installation prior to operation. The normal ventilation systems in the ESF building are in continuous operation and, therefore, periodic testing is not necessary.

The ESF building emergency ventilation subsystems are not in operation under normal conditions. These ventilation systems are interlocked with the equipment they are serving, and start whenever their respective equipment starts. Therefore, these systems are tested and verified to be operating at the same time that the equipment is tested.

9.4.5.5 Instrumentation Requirements

The ESF building normal ventilation system fans are controlled manually and operate continuously. Control devices and indicating lights are located on their respective motor control centers. Electric unit heaters in the ESF building areas are automatically controlled by thermostats to maintain a 50°F minimum temperature. A temperature controller modulates an electric duct heater in the mechanical rooms air intake to maintain a 50°F minimum supply air temperature whenever the fans are operating.

A safety injection signal overrides the manual control and closes the normal ventilation inlet and outlet dampers for the safety injection pumps, quench spray pumps and residual heat exchangers areas, and the containment recirculation pumps and coolers areas. In addition to the control indicating lights on the main ventilation panel located in the main control room, ESF status lights are provided on the main control board for each set of dampers to indicate they are both closed.

The safety related self contained air conditioning units for the ESF building emergency ventilation subsystems may be controlled manually from the main ventilation panel. These units start automatically when any of the ESF equipment in their areas is started. In addition to the control indicating lights on the main ventilation panel, status indicating lights are provided on the main control board for each air conditioning unit, to indicate when a unit is running.

The auxiliary feedwater pumps area emergency ventilation fans may be controlled manually from the main ventilation panel. Also, one train starts automatically whenever any of the equipment in its associated area is started. In addition to the control indicating lights on the main ventilation panel, an ESF status light is provided on the main control board to indicate when an emergency ventilation supply fan is running. A bypass alarm is actuated whenever both Train A supply and exhaust fans and Train B supply and exhaust fans are not available for operation.

When the auxiliary feedwater pumps area emergency ventilation system is operating, outside air is used exclusively until the supply air temperature decreases to 50°F d.b. At this point, the supply, exhaust, and recirculation dampers modulate the incoming outside air with a portion of the recirculated area air to maintain a 50°F d.b supply air temperature. In addition to the damper position indicating lights on the main ventilation panel, ESF status lights are provided on the main control board to indicate that either the supply or exhaust ventilation damper and the recirculation damper are fully closed.

Temperature switches are provided in each ESF area which actuate an annunciator at the main ventilation panel whenever an area temperature exceeds a predetermined set point. The switches are also monitored by the plant computer.

The ESF building normal ventilation discharge is monitored for gaseous radiation and sampled for particulate and iodine releases. The radiation monitors are discussed in Section 11.5.2.2. Air flow is measured and monitored by the RMS computer system.

Pressure differential indicators are provided for each inlet filter in the normal ventilation systems and in the inlet filters for self contained air conditioning units to monitor the filter condition. The inlet filter for the auxiliary feedwater pumps emergency ventilation system is equipped with a pressure differential switch which energizes an annunciator on the main ventilation panel as a result of high differential pressure. This switch is also monitored by the plant computer.

9.4.6 EMERGENCY GENERATOR ENCLOSURE VENTILATION SYSTEM

The emergency generator enclosure has both safety related and non safety related ventilation systems (Figure 9.4–3) which provide an acceptable environment for personnel and equipment operation.

9.4.6.1 Design Bases

The design bases for the emergency generator enclosure ventilation system are:

1. The ability to remove the heat generated by the operation of the emergency generator to meet the indoor design temperatures listed below.

2. Outdoor air design conditions are listed in FSAR Section 9.4.

3. The emergency generator enclosure summer indoor design temperature is 104°F during emergency generator operation. The winter indoor design temperature is 50°F during emergency generator standby condition.

4. General Design Criterion 2, as related to structures housing the system, and the system itself being capable of withstanding the effects of natural phenomena such as earthquake, tornadoes, hurricanes, and floods, as established in Chapters 2 and 3.

5. General Design Criterion 4, with respect to structures housing the system, and the system itself being capable of withstanding the effects of environmental conditions and internally generated missiles, pipe whip, and impingement forces associated with pipe breaks.

6. Nuclear safety related areas are in accordance with General Design Criterion 5, as related to shared systems and components important to safety.

7. Regulatory Guide 1.26, as related to the quality group classification of system components.

8. Regulatory Guide 1.29, as related to the seismic design classification of system components.

9. All ventilation intakes and outlets provided with concrete missile protected hoods.

9.4.6.2 System Description

There are two safety related and two non safety related ventilation systems, one each per emergency generator enclosure. The respective safety related system automatically starts upon start of the emergency generator diesel engine, provided the temperature in the associated enclosure rises above 65°F. Each safety related ventilation system consists of two 50 percent capacity supply fans and electrohydraulically operated inlet air, recirculating air, and exhaust air dampers. Each fan provides 60,000 cfm of supply air. The only ductwork in this system is the mixing plenum, which mixes the outside air with the recirculated air and a short stub between the exhaust dampers and the tornado dampers through the concrete floor at elevation 52 foot 0 inches. There are two electrohydraulically operated exhaust dampers per enclosure.

The supply fans introduce mixed inside and outside air into the enclosure, forces air out of the enclosure through the exhaust dampers and then through the muffler enclosure to the outdoors. This flow, through the muffler enclosure, carries away the heat rejected by the emergency generator combustion air exhaust muffler. All equipment and ductwork in this ventilation system are seismically designed and supported. All ventilating systems are provided with tornado dampers.

Each enclosure also has a non safety ventilation system which consists of one exhaust fan, ductwork and a backdraft damper. This system operates when the emergency generator is not operating. Each of these ventilation systems consists of a 2,000 cfm exhaust fan that draws air into the enclosure through building infiltration. The air is discharged to the outdoors through a backdraft damper, a tornado damper and the muffler enclosure at elevation 51 foot 0 inches. Although the system is non safety related, it is seismically supported in order to prevent damage to safety related equipment during a seismic event.

Heating is provided to the emergency diesel generator enclosure by three 20 kW and one 15 kW electric unit heaters for the north enclosure and three 15 kW and one 20 kW electric unit heaters for the south enclosure. Space temperature is maintained at approximately 50°F, when outside temperature is at minimum design condition.

9.4.6.3 Safety Evaluation

Each safety related emergency generator enclosure ventilation system is powered from a separate emergency electrical power train. Each safety related ventilation system receives its emergency power from the electrical bus that is supplied by the corresponding emergency generator; therefore, ensuring the removal of heat generated by emergency generator operation. In the event of damper control failure, the electrohydraulically operated air inlet and/or exhaust dampers fail in the open position, while the recirculation damper fails in the closed position. In the event of a failure of the heating and ventilation system, in either of the safety related enclosures, an enclosure temperature switch alarms in the control room, when that enclosure temperature exceeds 110°F or falls below 52°F. Run status lights are provided in the control room for the safety related fans.

The non safety related ventilation system is not required for safe shutdown of the plant. However, its failure to remain in position during a seismic event could jeopardize safety related equipment. Therefore, both the ventilation system and the unit heaters are seismically supported.

9.4.6.4 Inspection and Testing Requirements

After installation was completed, all fans were tested by operating them as separate components and as integrated systems with their inlet, exhaust, and/or recirculation dampers. Airflow measurements were taken to ensure that the specified design capacity was achieved.

The non safety related ventilation system operates continuously when the emergency generator is in a standby mode. The system can be shut down for inspection of wear, bearing alignment, bearing lubrication of fans and dampers, and inspection of dampers for free operation and tightly closing blades.

Periodic surveillance testing and preventative/corrective maintenance are performed on the emergency generator safety related ventilation systems to ensure proper and reliable operation.

9.4.6.5 Instrumentation Requirements

The emergency generator enclosure ventilation system operating parameters are monitored, indicated, and controlled locally and remotely, as follows:

> Both supply fans automatically start when the respective emergency generator diesel engine is running at a rate greater than 360 rpm and the ambient room temperature is above 65°F. When the supply fans have started, the temperature controller modulates the inlet damper, the recirculation damper, and both outlet dampers to maintain temperature below the profile outlined in FSAR Appendix 3B, Environmental Design Conditions, in the emergency generator enclosure. The temperature controller requires single or dual fan operation to modulate the dampers. When the emergency generator diesel engines have stopped (less than 360 rpm), the supply fans are stopped manually from the main heating and ventilation panel in the control room. The inlet damper goes to the fully closed position, the outlet and recirculating dampers go fully close and open, respectively.

Status lights are provided on the main board in the control room for the following:

1. Emergency generator enclosure supply fans operating

2. Inlet damper not fully closed, and recirculation damper not fully open

3. Both outlet dampers not fully closed

Annunciation is provided on the main heating and ventilation panel in the control room when the emergency generator enclosure temperature is either greater than 110°F or less than 52°F.

Indicator lights are provided on the main ventilation and air conditioning panel in the control room for the status of each supply fan and for the position of each damper.

Unit heaters are also provided in the enclosures to maintain temperatures above 50°F. The non safety related exhaust fans run continuously and are manually controlled from a local switch.

9.4.7 CONTAINMENT STRUCTURE VENTILATION SYSTEM

The containment structure ventilation system (Figure 9.4–5) consists of four separate subsystems which are described in the following order:

1. Containment air filtration subsystem
2. Containment air recirculation subsystem
3. Containment purge air subsystem
4. Control rod drive mechanism ventilation and cooling subsystem

9.4.7.1 Containment Air Filtration Subsystem

The air filtration portion of the containment ventilation system filters the containment atmosphere to reduce the concentration of airborne radioactive particulates and iodine to permit containment access.

9.4.7.1.1 Design Bases

The design bases for the containment air filtration subsystem are in accordance with the following:

1. Subsystem designated nonnuclear safety (NNS) as described in Section 3.2
2. Regulatory Guide 1.29 for seismic design classification of systems, structures, and components (Section 1.8)
3. Regulatory Guide 1.140 for air filtration and adsorption units (Section 1.8)

9.4.7.1.2 System Description

The containment air filtration subsystem includes two 100 percent capacity fans and filter banks. The fans are rated at 12,000 cfm each. Each filter bank includes a heater, prefilter, carbon adsorber, and two high efficiency particulate air (HEPA) filters.

The prefilter has a minimum efficiency of 80 percent by ASHRAE Standard 52. The carbon adsorber is constructed of stainless steel casing, is gasketless, and of nontray type. The carbon bed is 4 inches thick and is designed for 0.25 second dwell time per 2 inch depth of charcoal for gases at a flow velocity of 40 fpm. The impregnated charcoal is capable of removing over 99 percent of methyl iodide (CH I) and 99.5 percent of elemental iodine with air inlet conditions of 70 percent relative humidity and temperature of 77°F (25°C). The HEPA filters have a minimum filter efficiency of 99.97 percent when filtering particulates 0.3 micron or larger in size. Air is drawn into the filter units from the low elevations of the containment and discharged by the fans to the upper elevation.

The air filtration system design is based on reducing the containment atmosphere I-131 concentrations to below 1 EC (Effluent Concentration) in 16 hours using 1 unit under the conditions of reactor coolant leakage discussed in Section 12.3.3.1. Design conditions of the containment air filtration subsystem are given in Table 9.4–8.

9.4.7.1.3 Safety Evaluation

The containment air filtration subsystem, during normal plant operation and shutdown conditions, removes both radioactive particulates and iodine gases released to the containment air to enable access to the containment. Although the system is not safety related, the filter bank contains features essential for efficient operation, personnel safety, and maintenance. When one fan fails to operate, the redundant fan and filter are manually placed into operation. The redundant fans and filter banks are operated alternately to ensure equal wear.

9.4.7.1.4 Inspection and Testing Requirements

The filter casing and filters are factory and site tested as follows:

1. The filter housings were field tested for leak tightness to meet the leakage requirements of ANSI N509, “Nuclear Power Plant Air Cleaning Units and Components.”

2. The HEPA filters are tested for efficiency using the DOP method before leaving the manufacturer’s facilities and are checked for leakage after installation.

3. The carbon adsorbers are factory-tested for efficiency and checked for leakage after installation.

4. The airflow distribution within the filtration units was tested for uniformity after installation.

5. Provisions are included to remove representative carbon samples for laboratory testing to ensure that adequate capacity exists for the removal of radioiodines.

6. The fans were also tested after installation. Routine maintenance and surveillance are performed to ensure their operability.

9.4.7.1.5 Instrumentation Requirements

The containment air filtration system operating parameters are monitored, indicated, and controlled locally or remotely, as follows:

> The containment air filtration fans are controlled from the main heating and ventilation panel in the control room by ON-OFF control switches with indicating lights. The containment air filter cooling bleed damper is also controlled from that panel by pushbuttons with indicating lights.
>
> The main heating and ventilation panel in the control room also contains an annunciator which alarms on high differential pressure across any filter in the filter banks.

Computer inputs are provided to monitor the following:

1. Containment structure air filtration fans running
2. Containment structure air filtration fans stopped
3. Containment structure prefilter differential pressure high
4. Containment structure upstream HEPA filter differential pressure high
5. Containment structure charcoal filter differential pressure high
6. Containment structure downstream HEPA filter differential pressure high

The filter heater is controlled automatically by a temperature switch and is protected from over temperature by a temperature switch that must be manually reset locally. The filter heater is interlocked with a filter fan running signal.

High temperature in the charcoal filter is alarmed on the ventilation panel VP1 in the control room.

The differential pressure across each filter section is indicated locally.

The containment atmosphere airborne radiation monitor (Section 12.3.4) alerts the operator when either the normal gaseous or airborne particulate radiation level is exceeded and operation of the containment air filtration subsystem is required.

9.4.7.2 Containment Air Recirculation Subsystem

The air recirculation portion of the containment ventilation system is designed to maintain the bulk air temperature in the containment suitable for personnel and equipment operation during normal plant operation and for equipment operation following loss of off site power.

9.4.7.2.1 Design Bases

The design bases of the containment air recirculation subsystem are in accordance with the following criteria:

1. General Design Criterion 2 for protection against natural phenomena (Chapters 2 and 3).

2. Regulatory Guide 1.26 for the quality group classification of system components (Section 1.8).

3. Regulatory Guide 1.29, for the seismic design classification of system components (Section 1.8).

4. Subsystem designated as NNS. The air recirculation fans are Seismic Category I. Two fans are supplied from the emergency power buses. Tables 9.4–9 and 9.4–10 give the modes of operation and design conditions of the containment air recirculation system.

9.4.7.2.2 System Description

The containment air recirculation subsystem consists of three containment air recirculation unit coolers with an air distribution ductwork. Each unit cooler consists of one fan and six cooling coils. Its performance characteristics are given in Tables 9.4–9 and 9.4–10.

Each fan draws air across the cooling coil assembly and discharges the air to a common duct which distributes it through secondary ducts to different levels of the containment. During normal operation, two of three containment recirculation unit coolers operate. After a loss of off site power, one or two containment recirculation unit coolers operate.

The cooling coils in each recirculation unit cooler assembly are served by the plant chilled water system at 45°F during normal plant operation and by component cooling water at 95°F after a loss of off site power or a SIS (CIA).

The electrical power is supplied from redundant emergency buses for two units and from the normal bus for the third unit.

9.4.7.2.3 Safety Evaluation

Two of the three containment air recirculation unit coolers are required to maintain the containment average temperature below 95°F. If one unit fails, the remaining two units maintain the average temperature below 95°F during normal operation.

Units A and B are supplied with emergency power. During a loss of off site power, these unit coolers can operate with emergency power maintaining an average air temperature of the containment below 135°F. The CAR system is seismically supported and the fans are seismically qualified.

9.4.7.2.4 Inspection and Testing Requirements

The containment air recirculation subsystem was inspected, tested, and air-flow balanced during construction. The entire water system was hydraulically tested for leakage and the water flow to the cooling coils was properly balanced.

The cooling coils were pressure and leak tested. Since the system is continuously in operation, periodic testing is not required.

9.4.7.2.5 Instrumentation Requirements

The containment atmosphere recirculation system operating parameters are monitored, indicated, and controlled, locally or remotely, as follows:

> The containment air recirculation fans are controlled from the main heating and ventilation panel in the control room by START-STOP control switches with indicating lights. The A & B fans can also be controlled at the switchgear by START-STOP control switches with indicating lights. The switchgear also contains the REMOTE-LOCAL transfer switches for selecting which panel has control of these fans. An annunciator is alarmed on the main heating and ventilation panel in the control room when LOCAL control is selected for the A or B fans.

Annunciators are provided on the main heating and ventilation panel for the following system parameters:

1. Containment air recirculation fan auto trip
2. Containment air recirculation fan airflow low
3. Containment air recirculation cooling coil water flow low

Indicators are provided on the main heating and ventilation panel to monitor the containment air recirculation cooling coil chilled water discharge temperature.

The containment atmosphere recirculation fans A and B are started automatically on receipt of a sequenced safeguard signal from the emergency diesel generator load sequencer. A sequenced safeguard signal is initiated whenever an SIS or LOP signal exists.

The containment atmosphere recirculation fans A and B are stopped automatically on receipt of a CDA signal, even if the SIS or LOP signal has previously started the fans.

Component cooling water is provided to the containment atmosphere recirculation cooling coils instead of chilled water on receipt of an LOP or CIA signal. The cooling water flow is controlled by a temperature sensor installed in the return airflow.

A temperature element installed in the outlet airflow of each containment air recirculation cooling coil provides input data to the computer.

9.4.7.3 Containment Purge Air Subsystem

The containment purge air subsystem is designed to reduce the airborne radioactivity in the containment, and to provide outdoor air during extended periods of occupancy, such as refueling. It also provides the flow path for containment pressurization during containment leak testing as well as for containment repressurization to atmospheric conditions following reactor cooldown.

9.4.7.3.1 Design Bases

The design bases for the containment purge air subsystem are in accordance with the following criteria:

1. Provision for approximately one change of containment free air volume every hour.

2. Air supplied at a rate consistent with reducing airborne activity to as low as reasonably achievable.

3. Supply air maintained above 70°F, with heating supplied as required.

4. The containment penetrations, the containment isolation valves, their controls, and the piping between the valves are Safety Class 2 (SC-2). The remainder is nonnuclear safety (NNS). The ductwork within the containment building is seismically supported.

5. The purge system exhaust is provided with connections to charcoal filters to filter the exhaust before releasing to atmosphere, if necessary.

9.4.7.3.2 System Description

The containment purge air subsystem consists of a supply and an exhaust subsystem. Its performance characteristics are given in Table 9.4–11.

The purge air is supplied from the two 50 percent capacity supply units installed in the auxiliary. The units supply a total of 35,000 cfm.

The exhaust consists of two 50 percent capacity exhaust fans. The exhaust fans have a capacity of 35,000 cfm, enough to handle approximately one air change of the containment per hour.

The purge air system supply pipe is provided with a separate pipe connected to atmosphere. This pipe connection is used to raise the containment pressure during shutdown. It is also used as an air supply line for containment pressurization during containment leakage testing (Section 6.2.6).

The containment purge air subsystem exhaust is also provided with a connection to the auxiliary building filter units which contain prefilters, particulate filters, and charcoal filters. This enables the system to filter the exhaust if radioactivity is detected and ensures that no radioactivity beyond the allowable limits is released to atmosphere.

During unit shutdown, this system is manually actuated from the main control room if radioactivity levels within the containment are high enough to require purging before personnel entry. This system also functions as heating and ventilating system during periods of refueling and maintenance.

Supply and exhaust ductwork have butterfly isolation valves. During normal operation of the plant, the purge circuit is inoperative and the isolation valves are closed.

9.4.7.3.3 Safety Evaluation

During normal plant operation, the containment isolation valves are closed and the containment is not purged. The isolation valves are opened and purge system is started manually from the main control room only during cold shutdown. Area radiation monitors are provided on the operating deck of the containment with the capability of containment isolation. When high airborne radioactivity preclude the unfiltered discharge of purge exhaust air due to limits on site instantaneous release rates, an operator can divert the containment exhaust air through the main filter banks in the auxiliary building. Isolation or filtration are not credited in the fuel handling accident per Section 15.7.4.

Annunciators and indicators in the main control room permit the control operator to position the dampers correctly so that the exhaust passes through the filter bank before being released to atmosphere if there is any radioactivity detected in the containment air.

The exhaust duct length from the intake to the containment isolation valve is sufficient to ensure that the containment isolation valves are closed before radioactivity passes through them.

9.4.7.3.4 Inspection and Testing Requirements

The containment isolation valves for the purge air subsystem are tested for leak tightness as part of the containment leak testing program for Type C test, as described in Section 6.2.6.

The exhaust ductwork was also leak tested in accordance with the procedures delineated in Chapter 8, Leak Testing, of the Manual for the Balancing and Adjustment of Air Distribution Systems, published by SMACNA, 1967.

Testing and inspections of safety class 2 containment penetrations and isolation valves are covered in FSAR Section 6.2.6 and 6.6.

9.4.7.3.5 Instrumentation Requirements

The containment purge air system operating parameters are monitored, indicated, and controlled, locally or remotely, as follows:

> The containment purge heating and ventilation air supply units are controlled manually from the main heating and ventilation panel in the control room by START-STOP control switches with indicating lights. These switches are also interlocked to open or close the inlet dampers to the unit being operated.
>
> Operation of the dampers on the outlet of the containment air purge exhaust fans are controlled by pushbuttons with indicating lights located on the main heating and ventilation panel. The pushbuttons operate the outlet dampers to open on the exhaust to the auxiliary building filter system filter banks or on the exhaust directly to the atmosphere, or to close both sets of exhaust dampers. The containment purge air exhaust fans are interlocked with the dampers to start when both dampers in the same exhaust line are fully open. Indicating lights of the exhaust fans are provided on the main heating and ventilation panel in the control room.
>
> Containment purge inlet and outlet isolation valves are controlled from the main heating and ventilation panel by OPEN-AUTO-CLOSE keylock control switches with indicating lights. The switch key is locked in the AUTO position. The containment purge inlet and outlet isolation valves are designed to be automatically closed on receipt of a high radiation signal from the containment purge air exhaust radiation monitors, although isolation is not credited for the fuel handling accident per Section 15.7.4.
>
> Annunciators are provided on the main heating and ventilation panel for a reactor plant ventilation trouble alarm which is actuated by a containment purge heating and ventilation air supply unit heating coil discharge air temperature low. This condition also actuates a first out annunciator on the auxiliary building ventilation panel.

Engineering safety features status lights are provided on the main control board in the control room for the following:

1. Containment purge heating and ventilation inlet dampers open.
2. Auxiliary building filter system inlet dampers from containment purge system and containment purge system, normal outlet dampers.

Containment purge inlet and outlet isolation valve positions are monitored by the plant computer.

9.4.7.4 Control Rod Drive Mechanism Ventilation and Cooling Subsystem

The control rod drive mechanism (CRDM) cooling system is a forced air cooling system provided for removal of heat from the CRDM magnetic coils using cooling water from the plant chilled water system (Section 9.2.2.2).

9.4.7.4.1 Design Bases

The CRDM cooling system is designed in accordance with the following requirements:

1. Maintains the temperature of the stationary and moveable gripper and lift coils wiring insulation below allowable maximum of 392°F during normal reactor operation.

2. Supplies cooling airflow in the situation where the normal power supply is interrupted and the reactor is maintained at hot standby.

3. System designated non safety related (NNS), except for the power supplies for two of the three cooling fans.

9.4.7.4.2 System Description

The CRDM cooling system is a forced air cooling system which provides a reliable supply of cooling to the CRDM magnetic coils during normal reactor operation.

Cooling is provided by the CRDM cooling system which draws containment ambient air through the shroud and detachable ductwork. The CRDM cooling system contains three 50 percent fans, cooling coils, and duct plenum. The fans draw air through the cooling coils and discharge it to the containment. All fans are operable, and two of them have emergency power connections. Table 9.4–12 gives the performance characteristics.

9.4.7.4.3 Safety Evaluation

During normal conditions, two fans are in operation to supply 90,000 cfm (minimum) design airflow through the CRDM coils area. The CRDM cooling system is not a safety related system; however, two fans are powered from the emergency buses. This ensures airflow and cooling during loss of off site power to prevent damage to the CRDM components by limiting the maximum temperature in the magnetic coils. During loss of power no cooling water is available to the CRDM cooling coil assembly. Absorbed heat from the CRDM is rejected to containment atmosphere thus becoming a load on the air recirculation system.

9.4.7.4.4 Inspection and Testing Requirements

The system was tested and inspected as separate components and as an integrated system before installation. Upon initial startup testing of the fans, the airflow was measured at a value significantly above design and was accepted.

Capacity and performance of fans were tested and rated in compliance with Air Moving and Conditioning Association (AMCA) requirements.

Since the system is continuously in operation, periodic testing is not required.

9.4.7.4.5 Instrumentation Requirements

The control rod drive mechanisms (CRDM) cooling system operating parameters are monitored, indicated, and controlled, locally or remotely, as follows:

> The CRDM cooling fans are controlled from the main heating and ventilation panel in the control room by START-STOP control switches with indicating lights. Indicating lights for the fans are also provided at the switchgear.

Annunciators are provided on the main heating and ventilation panel for the following:

1. CRDM cooling fan local control
2. CRDM cooling fans auto trip
3. CRDM shroud temperature high
4. CRDM shroud cooler outlet flow low

There are indicators on the main heating and ventilation panel for the CRDM shroud temperature.

Control of the cooling water to the CRDM shroud cooler is accomplished at the main board in the control room. Pushbuttons with indicating lights are provided to operate the CRDM shroud cooler inlet valve.

The following system parameters are monitored by the plant computer:

1. CRDM cooling fan local control
2. CRDM cooling fan auto trip

The CRDM fans stop automatically upon receipt of an LOP signal or containment depressurization actuation (CDA) signal. The CRDM fans will start automatically on receipt of a sequenced safeguard signal from the emergency generator load sequencer (Section 8.3).

9.4.8 CIRCULATING AND SERVICE WATER PUMPHOUSE AND OTHER YARD STRUCTURES VENTILATION SYSTEMS

9.4.8.1 Circulating and Service Water Pumphouse Ventilation System

The circulating and service water pumphouse (Figure 9.4–3) has both safety and non safety related ventilation systems, which provide a suitable environment for personnel and equipment. Each service water pump cubicle has a safety related ventilation system. The remaining areas of the pumphouse are served by non safety related ventilation systems.

9.4.8.1.1 Design Bases

The design bases for the circulating and service water pumphouse ventilation system are:

1. The ability to maintain an environment suitable for personnel and equipment located in the area.

2. The outside air summer-design temperature for the Millstone Point site of 86°F and the outside air winter-design temperature of 0°F.

3. The summer indoor design temperature coincident with 86°F outside temperature is 104°F during normal operation with one service water pump running. The winter indoor design temperature is 40°F during normal operations and 50°F during maintenance periods. In a post LOCA mode of operation with two service water pumps running, the summer indoor design temperature is 119°F.

4. In accordance with General Design Criterion 2 for structures housing the system, and the system itself being capable of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods, as established in Chapters 2 and 3.

5. In accordance with General Design Criterion 4 for structures housing the system, and the system itself being capable of withstanding the effect of external missiles and internally generated missiles, pipe whip, and jet impingement forces associated with pipe breaks.

6. Nuclear safety related areas are in accordance with General Design Criterion 5 for shared systems and components important to safety. No systems or components are shared. A single active failure cannot result in loss of the system functional performance capabilities.

7. In accordance with Regulatory Guide 1.26 for the quality group classification of system components.

8. In accordance with Regulatory Guide 1.29 for the seismic design classification of systems components.

9. In accordance with Regulatory Guide 1.89 as described in IEEE 323-1974 for the environmental qualification of Class IE electrical equipment.

9.4.8.1.2 System Description

The service water portion of the pumphouse contains four service water pumps arranged with two pumps in each of two cubicles. Each cubicle contains its own safety related (QA Category I, Seismic Category I) ventilation system. Each service water pump cubicle ventilation system supplies and exhausts air through air inlets and discharges located on the roof. The air inlet and exhaust ductwork is seismically supported and designed and is provided with sound attenuators to reduce noise emission from the service water section of the pumphouse. The system operates in either a summer or winter mode by manually repositioning a balancing damper located downstream of the fan in the spring and fall respectively. Each 100 percent fan provides 16,500 cfm total flow in the summer and 15,500 cfm total flow in the winter. In either mode, an access door located downstream of each fan is permanently removed to recirculate partial air flow (8,300 cfm summer and 12,400 cfm winter). Based on this recirculation flow a net exhaust flow of 8,200 cfm summer and 3,100 cfm winter is achieved. Air enters each cubicle through a roof mounted air-operated damper and silencer. All air operated dampers fail in the open position. Emergency power is supplied to each service water pump cubicle by a separate independent train. Each train supplies power to the ventilation system and the service water equipment within that cubicle. Each ventilation system exhaust fan is operated by means of a temperature control switch which maintains the service water pump cubicle at the desired temperature.

The two cubicles are separated from each other and from the circulating water pump section of the pumphouse by missile and flood barriers.

The air intake and exhaust hoods for each service water cubicle ventilation system are protected from tornadoes and floods and are designed to withstand a safe shutdown earthquake.

Heating is provided to the service water cubicles by an electric heater in each cubicle to maintain space temperature above 40°F. Heating of the service water pump cubicles is not essential and is not safety related nor seismically designed. Heaters in the service water pump cubicle are seismically supported so that damage to the essential portions of the service water pump cubicle ventilation system does not result from a seismic event creating heater generated missiles.

The circulating water portion of the pumphouse has six circulating water pumps arranged with three pumps at each end of the building. There are two 50 percent capacity ventilation systems, one serving each end of the circulating water side of the pumphouse. These systems supply outside air through wall intake louvers and exhaust the air through roof hoods. The air inlet and exhaust ductwork has sound attenuators installed to reduce noise emission from the circulating water section of the pumphouse. Each exhaust fan has a capacity of 51,000 cfm, and exhausts air through a backdraft damper to the outside. A temperature control switch cycles each system's exhaust fan and inlet damper to maintain the desired space temperature. One fan normally operates with the other fan in standby. The other fan operates in case one fan cannot maintain the desired space temperature or the running fan stops. Heating is provided to the circulating water section of the pumphouse by electric unit heaters and to the screenwash section of the pumphouse by infrared heaters in order to maintain space temperature to protect against freezing. The circulating water system, its pumphouse ventilation, and the heating system in the circulating water and screenwash sections are not essential to the safe shutdown of the plant and are not safety related.

The pumphouse also has a chlorine room which contains equipment for chlorination of the service water. The system supplies 1,100 cfm of outside air to the area through an air operated inlet damper, and the exhaust fan exhausts 1,100 cfm through a back draft damper to the outside. Two electric heaters heat the chlorine room to maintain space temperature above 50°F.

9.4.8.1.3 Safety Evaluation

The two service water cubicle ventilation systems are redundant with a separate emergency electrical power supply to each system.

The same emergency bus that powers the service water pumps powers the associated ventilation system. Emergency power ensures operation of the service water cubicle ventilation system in the event of a loss of off site power or unit shutdown. In the event of damper control failure, the air operated inlet dampers fail in the open position. In the event of a mechanical failure of either service water cubicle exhaust fan, a space temperature switch alarms in the control room when that cubicle temperature exceeds a predetermined set point. In the event that the space temperature falls below a predetermined set point a low temperature is sensed and alarms in the Main Control Room on the Plant Process Computer and the operator can take action to prevent any potential freezing problems. The loss of ventilation in a service water pump cubicle has no effect on the operation of the service water system equipment in that cubicle, providing action is taken in a timely manner after the space high temperature alarm is received in the control room. Complete failure of one service water pump cubicle ventilation system does not preclude a safe shutdown or mitigation of any accident by the service water system because the redundant service water pump cubicle ventilation system and the redundant service water system are operable.

9.4.8.1.4 Inspection and Test Requirements

All fans were tested by operating them as an integrated system with their associated air operated inlet dampers. Air flow measurements were taken to ensure that the specified design capacity was achieved. The service water cubicle safety related ventilation systems are functionally tested periodically.

9.4.8.1.5 Instrumentation Requirements

The circulating and service water pumphouse ventilation systems operating parameters are monitored, indicated, and controlled locally or remotely as follows:

Both service water pumphouse exhaust fans can be controlled manually from the main heating and ventilation panel in the control room. The fans are controlled by Category I temperature switches. The intake dampers are interlocked with their associated exhaust fan. The damper must be fully open for the exhaust fan to run.

Engineered safety features status lights are provided on the main control board, for each service water pumphouse exhaust fan, to indicate when an exhaust fan is not running.

Each service water pumphouse cubicle is provided with a high temperature annunciator on the main heating and ventilation panel in the control room. The annunciators are activated when the temperature exceeds 120°F.

Service water system bypass status indication is provided on the main control board which receives inoperability signals from the exhaust fans of the service water pump cubicles in accordance with Regulatory Guide 1.47. For a complete list of input signals, see Section 7.3.1.1.5.

Both circulating water pumphouse exhaust fans can be manually controlled at the main heating and ventilation panel in the control room. Normally, the fans are controlled automatically by two temperature switches. One fan is the lead fan and the second is a follow fan. The lead and follow fans can be selected manually at the main heating and ventilation panel. When the lead fan is unable to maintain temperature at a predetermined set point, the follow fan is automatically cycled on and off, as necessary. The inlet dampers of the circulating water pumphouse exhaust fans are interlocked with their associated exhaust fan. The inlet damper must be fully open for the exhaust fan to run.

Electric heaters in the service water pump cubicles and the circulating water pump area are automatically controlled by thermostats to maintain the temperature greater than 40°F.

9.4.8.2 Yard Structures Ventilation System

The yard structures ventilation system is shown on Figure 9.4–3, and includes the warehouse area, office, telephone exchange room, warehouse rest rooms, and elevator. The system is nonnuclear safety related.

9.4.8.2.1 Design Bases

The design bases for the yard structures ventilation system are as follows:

1. The yard structures ventilation system is a non safety related system (NNS). It is designed to provide a suitable environment for personnel and equipment.

2. The outdoor air design temperatures are listed in Section 9.4.

3. Air-conditioned spaces in the yard structures ventilation system include the telephone exchange room and office areas, and are designed to maintain a space temperature between 70°F-85°F in telephone exchange room and 75°F in office areas. The general warehouse area ventilation system provides four volume changes per hour by the use of ventilation fans.

9.4.8.2.2 System Description

The yard structures ventilation system consists of the following:

1. Warehouse area ventilation system.

2. Office areas air conditioning system.

3. Telephone exchange room air conditioning system.

4. The system also contains exhaust fans for the elevator penthouse and the restrooms.

5. Waste neutralization tank(s) exhaust system.

The warehouse area ventilation system includes a supply filter assembly, two supply fan silencers, two 50 percent capacity vane axial supply fans and one 100 percent capacity vane axial exhaust fan. The fans serve two levels through distribution ductwork. The 100 percent outdoor air is used to cool and ventilate this area. The ventilation fans are controlled by means of a temperature controller. Auxiliary heating is provided to this area by separate steam unit heaters.

The office areas, consisting of offices, store rooms, and classrooms are air-conditioned through individual variable air volume (VAV) boxes. The VAV boxes are serviced through a self contained air conditioning (A/C) unit, a return air fan and distribution ductwork. The A/C temperature is controlled by an electronic central panel monitoring the return air and the discharge air. Individual VAV boxes are controlled by a corresponding local thermostat.

The waste neutralization tank exhaust system consists of a corrosion proof exhaust fan dedicated to odor removal from the waste sumps.

The (NPRF) is provided with a dedicated halon fire protection system.

The telephone exchange room system consists of a self contained air conditioning unit and distribution ductwork. The space temperature is controlled by a room temperature controller which modulates the return and outdoor air damper, and the heating coil in the air conditioning unit.

9.4.8.2.3 Safety Evaluation

The ventilation and air conditioning system serving the yard structures ventilation system are non safety related systems and are not required to perform any safety function.

9.4.8.2.4 Inspection and Testing Requirements

The yard structures ventilation system was inspected during and after installation. The system was carefully tested and balanced to ensure the supply and return of the design air quantity.

The yard structures ventilation systems are designed to be normally in continuous operation. Therefore, they do not require any periodic testing. Visual inspections are conducted following regular system maintenance to confirm normal system operation.

9.4.8.2.5 Instrumentation Requirements

The yard structure ventilation systems operating parameters are monitored, indicated, and controlled, locally and remotely as follows:

1. The warehouse area exhaust fan starts automatically when the temperature increases above 85°F. The supply fans are interlocked to start when the exhaust fan starts. The exhaust and supply fans can also be controlled manually. Unit steam heaters are provided to maintain the area temperatures greater than 65°F.

2. The office areas air conditioning unit is controlled unit is controlled through a central electronic panel.

3. Individual VAV boxes servicing specific office areas are controlled by a corresponding local thermostat.

4. The telephone exchange room is provided with a separate air conditioning unit that can be manually selected to heat or cool the area, or to automatically maintain the temperature between 70°F-85°F.

5. The waste neutralization tank(s) exhaust fan (2HVY-FN5) is controlled by a local on/off switch.

9.4.9 WASTE DISPOSAL BUILDING VENTILATION SYSTEM

The waste disposal building ventilation system (Figure 9.4–2) provides a suitable environment for personnel and equipment operation as well as to minimize the release of airborne radioactive material to the atmosphere. The system is nonnuclear safety related.

9.4.9.1 Design Bases

The safety related portions of the waste disposal building ventilation system are designed in accordance with the following criteria:

1. Regulatory Guide 1.29 for seismic design classification of system components. Only those portions of the waste disposal building ventilation system located inside the auxiliary building and designated QA Category I are classified as seismic Category II system and designed to Regulatory Guide 1.75, Section 1.8. The safety related portions of the waste disposal building exhaust ventilation are located in the auxiliary building, a seismic and tornado protected structure. This system is capable of withstanding, or is protected from, the effects of external missiles and internally generated missiles.

2. General Design Criterion 2 for protection against natural phenomena.

3. General Design Criterion 5 for sharing of structures, systems, and components important to safety.

4. General Design Criterion 60, and Regulatory Guide 1.140 for control of releases of radioactive materials to the environment.

5. Branch Technical Positions ASB 3-1 and MEB 3-1. A break in high and moderate energy piping systems is not postulated within the waste disposal building. However, those portions of the waste disposal building ventilation system classified as QA Category I and located inside the auxiliary building are subject to the environmental conditions resulting from this type of accident.

   The waste disposal building ventilation system is also designed in accordance with the following criteria:

6. Outdoor air design temperatures of 86°F dry bulb for summer and 0°F dry bulb for winter.

7. During summer, coincident with the outdoor air design temperature, the space temperature is maintained at or below 90°F in the control area and 104°F in other areas. During winter, the indoor temperature is maintained at a minimum of 65°F.

8. Air within the building will be controlled to move from areas of low radioactivity to areas of progressively higher radioactivity.

9. Limitation of the release of airborne particulate radioactivity to the atmosphere by remote manual diversion of the exhaust air to the auxiliary building filter system (Section 9.4.2) upon receipt of a high radiation level in the exhaust air.

10. Areas subject to radioactive contamination are mechanically exhausted with natural supply from adjacent areas, thus maintaining a slightly negative pressure relative to the surrounding areas, minimizing the spread of the contamination as required by Regulatory Guide 1.143 (formerly BTP ETSB 11-1, Rev. 1) (Section 1.8).

11. The exhaust system air is monitored by a radiation monitor (Section 11.5).

9.4.9.2 System Description

The waste disposal building heating and ventilating system is shown on Figure 9.4–2. Principal component design and performance characteristics are listed in Table 9.4–13. The waste disposal building ventilation system is a once-through system using outside air as the ventilation and cooling medium and consisting of separate supply and exhaust subsystems.

The supply subsystem includes three 50 percent capacity heating and ventilating units and associated distribution ductwork. Each heating and ventilating unit consists of a medium efficiency filter, hot water preheating coil, hot water reheating coil, and centrifugal supply fan with associated controls. The air intake to each unit consists of air-intake hood, ductwork, and air-operated inlet damper. The three units are connected to a common discharge duct that supplies air to the fuel building and the waste disposal building. The supply portion to the waste disposal building is furnished with a flow controller that modulates an air-operated damper to maintain inlet airflow at a predetermined setting.

The exhaust subsystem consists of two axial fans with one operating and the other on standby. The exhaust duct system is arranged in such a manner that all exhaust air is drawn from areas with the highest radiation contamination potential, thereby inducing air flow from clean areas into potentially contaminated areas and maintaining the potentially contaminated areas at subatmospheric pressure. The exhaust air is monitored for radiation by the radiation monitor located in the plant vent stack and locally in the exhaust duct from the waste disposal building.

During normal plant operation, the exhaust air is directed to the ventilation vent stack, located on the turbine building, through a set of two air-operated dampers. Upon detecting a high radiation level in the exhaust system, the exhaust air is manually diverted to the auxiliary building filter system through a set of two air-operated dampers before being discharged to the atmosphere via the ventilation vent stack.

9.4.9.3 Safety Evaluation

Although the waste disposal building heating and ventilating system is not required for safe shutdown of the plant, the following features are incorporated in its design to ensure system reliability and to minimize the uncontrolled release of airborne radioactive contaminants during normal plant operation:

1. Three 50 percent capacity air heating and ventilating supply units are provided with two units operating and a third on standby. This design ensures full supply air capacity with one unit inoperative.

2. The potentially contaminated areas are maintained at a negative pressure with respect to surrounding cleaner areas to minimize the spread of radioactive contaminants.

3. Exhaust air is monitored for radiation level prior to discharge to the atmosphere. A high radiation level annunciates an alarm in the control room and, from the control room, the operator can manually divert the exhaust air to the auxiliary building filter system, thereby minimizing the release of radioactive contaminants to the atmosphere.

9.4.9.4 Inspection and Testing Requirements

The waste disposal building heating and ventilating system was inspected during construction to ensure proper installation. All components were inspected prior to installation to ensure that they complied with their design specification. The standby heating and ventilating unit is tested periodically to ensure its availability. The testing and balancing of this system was performed before putting the system into operation. Further testing is unnecessary since the system is operating continuously. The power-operated dampers located at the waste disposal exhaust fans discharge are tested monthly.

9.4.9.5 Instrumentation Requirements

The waste disposal building ventilating outlet dampers and auxiliary building filter inlet dampers have control switches and indicator lights on the main heating and ventilation panel in the control room. The filter inlet dampers from the waste disposal building exhaust close automatically on receipt of a SIS, LOP, or CDA signal.

Engineered safety feature status lights indicate, in the control room, when the filter inlet dampers are closed.

The waste disposal building exhaust fans have control switches and indicator lights on the auxiliary building ventilation panel. The exhaust fans are interlocked with the auxiliary building filter inlet dampers and the waste disposal building ventilation normal outlet dampers. Either the filter inlet or the normal outlet dampers have to be open to run an exhaust fan. One fan is started manually with the other on standby. The standby fan starts automatically on low air flow in the associated ductwork of the running fan.

A proportional controller is used to modulate the waste disposal building ventilation inlet damper. The controller maintains air flow to the waste disposal building at a predetermined setpoint, provided one of the waste disposal building exhaust fans is running. The damper is interlocked to close when both exhaust fans are stopped.

The waste disposal building heating and ventilation supply fans have control switches and indicator lights on the auxiliary building ventilation panel. The inlet dampers are opened and closed when the associated supply fan control switch is placed in the ON and OFF position, respectively. For freeze protection, a temperature switch monitors air temperature at the outlet of the hot water preheater and automatically closes the inlet damper when the temperature drops to 35°F. The inlet dampers are interlocked to start the supply fan when open and stop the supply fan when closed. Low inlet air temperature is alarmed on the auxiliary building ventilation panel and an auxiliary building ventilation trouble annunciator is alarmed on the main heating and ventilation panel in the control room.

Waste disposal area ventilation exhaust is monitored by radiation monitors and high radiation is alarmed locally and in the control room.

9.4.10 MAIN STEAM VALVE BUILDING VENTILATION SYSTEM

The main steam valve building ventilation system (Figure 9.4–4) provides a suitable environment for personnel, equipment operations and controls during normal operation and for safety related equipment during loss-of-off site power (LOP) transients and upon safety injection signal (SIS) initiation.

9.4.10.1 Design Bases

The design bases of the main steam valve building ventilation system are as follows:

1. During normal summer and winter operation, the building's indoor design temperatures are 120°F and 40°F, respectively. The maximum normal operating temperature is 120°F. The maximum normal excursion (NME) temperature is 140°F for eight hours based on an LOP transient. The maximum MSVB maximum design temperature is 240°F based on concurrent LOP, SSE, and single failure of one of two safety-related MSVB exhaust fans. The latter design condition is used in the qualification of safety related equipment in the main steam valve building to the requirements of IEEE-323-1974. (Also reference Branch Technical RSB 5-1 and FSAR page Q440.24-1.) In addition, the environmental conditions resulting from a main steam line break in the Main Steam Valve Building are also applied in the qualifications of safety related equipment in the main steam valve building to the requirements of IEEE-323-1974.

2. To minimize the release of airborne radioactivity after a postulated design basis accident (DBA), the building is maintained at a slight negative pressure after a complete shutdown of the normal ventilation exhaust and air intake systems by exhausting air using the supplementary leak collection and release system (SLCRS) discussed in Section 6.2.3 in conjunction with the auxiliary building ventilation system discussed in Section 9.4.2.

3. Portions of the ventilation system required to operate during LOP for maintaining the equipment environment are designated QA Category I. They are connected to the safety related Class IE power supply.

   The safety related portions are isolated from the non safety related portions of the system and are missile protected.

4. The safety related portions of the ventilation system are in accordance with the requirements of General Design Criterion 4 of 10 CFR 50 Appendix A. Both the system and housing structures are capable of withstanding the effects of either externally or internally generated missiles as well as jet impingement forces associated with either pipe whip or a pipe break.

5. The QA Category I portion of the ventilation system is in accordance with the requirements of General Design Criterion 5 of 10 CFR 50 Appendix A, for shared systems and components important to safety.

6. The QA Category I portion of the ventilation system is in accordance with the requirements of IEEE-323-1974 for qualifying Class IE electrical equipment.

7. The safety related portion of the ventilation system is in accordance with the requirements of Regulatory Guide 1.29, for the seismic design of systems components.

9.4.10.2 System Description

Figure 9.4–4 shows the main steam valve building (MSVB) heating, ventilation, and air conditioning (HVAC) system.

This system, consists of a natural air supply with a mechanical exhaust subsystem and a spot cooling subsystem. The supply/exhaust subsystem consists of four axial flow fans and two intakes with dampers, heating coils, and associated ductwork. Two fans, each rated to handle approximately 16 percent of the normal ventilation load, are powered from the normal power supply. The other two fans, each rated to handle approximately 34 percent of the normal ventilation load, are powered from the Class IE power supply. Each safety related fan has a discharge back draft damper arranged in series with an inlet emergency powered, motor operated damper. Each non safety related fan has inlet and discharge Class IE powered air operated dampers arranged in series to meet single-failure criteria (LOP with one damper failing open). Each intake assembly consists of two Class IE powered motor-operated dampers in series. associated ductwork, and a hot water heating coil with pneumatically operated integral face and bypass dampers controlled by a non safety related temperature controller. Redundant, safety-related temperature switches are located at the discharge of each heating coil to close the redundant intake dampers on sensing subfreezing air temperatures.

During normal operation, air enters the main steam valve building through the outdoor intake assemblies located on the outside wall at the lowest level of the structure. The air is drawn upward by the roof-mounted exhaust fans through various building levels to remove heat from the main steam and feed water piping and is discharged to the atmosphere. During winter operation, air drawn into the building is heated to a minimum of 40°F. Local hot water unit heaters are also installed.

Following LOP, both normally powered exhaust fans shut down, building intake dampers fail open, and Class 1E powered fans continue to operate and limit space temperature below equipment qualification temperatures.

Following an SIS, all exhaust fans are shut down, their associated Class 1E powered inlet and discharge dampers are closed, and the redundant building intake dampers are closed. These actions establish the integrity of the SLCRS boundary, allowing the SLCRS system to create a slight negative pressure within the MSVB.

The outdoor air intake and exhaust fan discharge penetrations are protected to prevent entry of a missile to the interior of the structure.

The spot cooling subsystem consists of a normally powered axial flow fan and distribution ductwork in each of the north and south bay of the MSVB. These fans take suction from elevation 41 feet 0 inches before the air has been significantly heated by process waste heat. The air is distributed to spot cool various safety-related equipment located at elevation 71 feet 0 inches and maintain the local temperatures below equipment qualification temperatures.

The bridge portion of the main steam valve building which connects to the turbine building is isolated from the ventilated portion of the building by doors and is neither heated nor ventilated. The floor of the structure in this area is steel grating which is open to the atmosphere, thereby subjecting the structure interior and contents to outdoor ambient conditions. All large piping in this area is drained when not in operation. Small piping is heat traced to prevent freezing.

9.4.10.3 Safety Evaluation

The main steam valve building ventilation system exhaust fans powered by the normal AC power supply are not required to operate during or after a postulated accident and are therefore not safety related. The failure of these fans does not interfere with operation of other safety related systems.

However, two of the ventilation exhaust fans and their associated components are connected to Class IE power supplies in order to permit their continued operation to mitigate the consequences of LOP transients. These components are designed and manufactured to QA Category I requirements to maintain the integrity of the Class IE power system.

Controls and actuations associated with building isolation and HVAC system shutdown during a DBA are safety-related and are connected to Class 1E power supplies. Redundant, independently powered, intake dampers installed at each building intake close on an SIS. Each safety related exhaust fan and its associated, independently powered inlet damper receive separate train SISs to shut down the fan and/or close its inlet damper ensuring integrity of the SLCRS boundary. The inlet and discharge dampers of each non safety related fan also receive separate train SIS to provide redundancy in isolation.

Controls and actuations associated with building intake dampers closure due to a loss of heating coil function are safety-related. Redundant, independently powered temperature switches are installed at the discharge of the heating coils set to close the intake dampers on sensing subfreezing temperatures. This ensures continued operability of main steam pressure sensing instrumentation and will prevent exposing other equipment in the building to subfreezing conditions.

Closure of a building intake damper causes shutdown of associated exhaust fans. Provisions are installed to allow administratively controlled restart of individual fans if intake damper closure was caused by failure of a temperature switch or one or both heating coils. This will prevent exceeding equipment qualification limits.

9.4.10.4 Inspection and Test Requirements

The main steam valve building ventilation system was air-leak tested, pressure tested in accordance with Specification for Installation of Ventilation and air conditioning Systems, air balance tested, adjusted and inspected for proper installation prior to operation. The automatic isolation feature of the exhaust system components and the outdoor intake assembly components are tested in accordance with the requirements of Technical Specifications.

9.4.10.5 Instrumentation Requirements

The main steam valve building ventilation system operating parameters are monitored, indicated, and controlled remotely. The spot cooling subsystem is controlled locally.

The exhaust fans and spot cooling fans of the MSVB operate continuously during normal operation.

The heating coil capacity is regulated by a pneumatically controlled face and bypass dampers which assume a "fail-to-heat" position on loss of instrument air supply. Local temperature switches actuate annunciators on the control room HVAC control panel alerting control room operators if coil discharge temperatures exceed prescribed limits.

Closure of intake damper(s) due to loss of hot water coil heating capability during subfreezing outdoor conditions will automatically stop the exhaust fans. Temperature switches actuate annunciators on the control room HVAC panel to alert operators to MSVB low inlet temperature. Manual fan switches on the control room HVAC panel provide control room operators the ability to individually restart exhaust fans during normal plant operating conditions if required to maintain building temperatures within allowable limits.

Control switches and indicating lights on the main heating and ventilation panel in the control room permit manual operation of all normal HVAC subsystem fans and dampers from the control room. The spot cooling subsystem is controlled from local control panels.

As a result of LOP condition, the normal powered components of the system automatically shut down, while the Class IE powered components continue to operate.

An SIS overrides both the manual and automatic controls, closing the inlet and outlet dampers of the main steam valve building and stopping the exhaust fans. Engineered safety features yellow status lights are provided on the main control board for each inlet and outlet damper to indicate that it is closed.

9.4.11 HYDROGEN RECOMBINER BUILDING HEATING, VENTILATION, AND AIR CONDITIONING (HVAC) SYSTEM

The primary functions of the hydrogen recombiner building HVAC system (Figure 9.4–2) are to provide a suitable environment for personnel and equipment operation and to mitigate the potential for a release of airborne radioactive material to the atmosphere. The hydrogen recombiner building post-accident exhaust system and the hydrogen recombiner portion of the HVAC system are nuclear safety related. The hydrogen recombiner system and associated post-accident exhaust system are installed, but not used for any mitigating function. The hydrogen recombiner system, associated controls, alarms (including Regulatory Guide 1.47 bypass alarms) and post-accident exhaust system ventilation equipment have been isolated awaiting abandonment. The system discussion describes the system as originally installed and operated. The hydrogen recombiner building (HRB) control room air conditioning (A/C) system, HVAC room ventilation system, and the building heating system are not safety related.

9.4.11.1 Design Basis

The design basis of the hydrogen recombiner building HVAC system is as follows:

1. The outdoor air design temperatures are listed in Section 9.4.

2. Indoor Design Conditions

   a. During normal summer operation, indoor design temperatures are:

Area	**Temperature**
HRB control room	75°F dry bulb
HVAC equipment room	104°F dry bulb
H_2 recombiner cubicles	Not controlled (110°F dry bulb maximum)
Sample room	Not controlled (104°F dry bulb maximum)

   b. During normal winter operation, indoor design temperatures are:

HRB control room	67°F dry bulb
HVAC equipment room	50°F dry bulb
H_2 recombiner cubicles	50°F dry bulb
Sample room	50°F dry bulb

   c. Automatic temperature control is provided for the operation of the system. Heating and cooling components are supplied by the normal power supply.

   d. The hydrogen recombiner skid-mounted package system includes a ventilation blower assembly maintaining the return process gas stream at ≤ 150°F.

   e. The HRB control room A/C system provides fresh air makeup.

3. The sample room can be maintained at a negative pressure by exhausting air through the hydrogen recombiner building post-accident exhaust system into the SLCRS system to minimize the release of airborne radioactivity after a design basis accident (DBA).

4. The hydrogen recombiner ventilation system and the hydrogen recombiner building post-accident exhaust system are nuclear safety related and are designated QA Category I. The control room air conditioning system, HVAC equipment room ventilation system, and all electric space unit heaters are non-nuclear safety related.

5. The QA and Seismic Category I portion of the HVAC system is in accordance with the requirements of General Design Criterion 2 for structures housing the system being capable of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods, as established in Chapters 2 and 3.

6. The QA and Seismic Category I portion of the HVAC system is in accordance with the requirements of General Design Criterion 4 for structures housing the system as well as the system being capable of withstanding the effects of external missiles and internally generated missiles, pipe whip, and jet impingement forces associated with a pipe break.

7. The QA and Seismic Category I portion of the HVAC system is in accordance with the requirements of General Design Criterion 5 for shared systems and components important to safety.

8. The QA and Seismic Category I portion of the HVAC system is in accordance with the requirements of IEEE-323-1974 for qualifying Class IE electrical equipment (Section 3.11B.1).

9. The QA and Seismic Category I portion of the HVAC system is in accordance with the requirements of Regulatory Guide 1.26, for the quality group classification of systems components (Section 3.2).

10. The QA and Seismic Category I portion of the HVAC system is in accordance with the requirements of Regulatory Guide 1.29, for the seismic design classification of system components (Section 3.2).

11. All ventilation intakes and exhaust outlets are provided with concrete missile protected hoods.

9.4.11.2 System Description

The hydrogen recombiner building HVAC system is shown on Figure 9.4–2. The system is comprised of the following subsystems:

1. Hydrogen recombiner ventilation (Skid Package 3HCS*RBNR1A/1B).

2. Control room air conditioning (3HVZ-ACU1).

3. HVAC equipment room ventilation system (3HVZ-FN1).

4. Hydrogen recombiner building heating (3HVZ-UHE1A/1B/2/3A/3B/4A/4B).

5. Hydrogen recombiner building post-accident exhaust system (Hoods' Sampling Modules 3SSP-SAS1/SAS2).

    a. The hydrogen recombiner ventilation system is a safety related QA-Category I system consisting of a ventilation fan which is an integral component of the hydrogen recombiner skid mounted package, supply and exhaust duct networks, a radiation monitor, and isolation dampers, all powered from Class IE power supply. During normal plant operation, the two redundant hydrogen recombiner skid-mounted package systems are not used. Use of the systems is also not credited following a design basis accident.

       Electro-hydraulic operated dampers (MOD) on the supply and exhaust duct lines are normally closed. The MODs on the supply and exhaust duct lines are manually activated by a hand switch located in the Main Control Room on the HVAC VP-1 Panel to open or close. The MODs through limit switches are interlocked with the recombiner package system allowing the system to start. However, upon receiving a high radiation signal from its exhaust duct radiation monitor, the corresponding isolation dampers close and the recombiner package system trips off. Both the hydrogen recombiner and the hydrogen recombiner ventilation fan are manually activated from individual "AUTO, OFF, HAND" switches mounted on the local hydrogen recombiner control consoles. The recombiner ventilation system is designed to maintain the process return gas stream to the containment atmosphere at ≤ 150°F.

    b. The hydrogen recombiner control room air conditioning system is non-nuclear safety related. The system consists of an evaporator-blower, air cooled condensing unit, an air filter, associated ductwork, and motor operated dampers. The system thermostatically operates to maintain the control room high temperature at approximately 75°F. Two electric heaters, each controlled by its own thermostat maintain the control room low temperature between 62°F and 72°F.

    c. The hydrogen recombiner HVAC equipment room ventilation system is non nuclear safety related. The system consists of a propeller exhaust fan, motor-operated supply and exhaust dampers, a supply air filter, and related ductwork. The system thermostatically operates to maintain the equipment room below 104°F.

d. The hydrogen recombiner building heating system is non-nuclear safety related. It consists of electric unit heaters located in all areas of the building providing a space temperature range of 45 to 55°F except for the hydrogen recombiner control room heaters that maintain a range from 62°F to 72°F.

e. The hydrogen recombiner building post-accident exhaust system serving the post-accident sampling module units (Section 9.3.2.6) is connected to the supplementary leak collection and release system (SLCRS) (Section 6.2.3). Whenever a sample is required, one of the SLCRS fans (Figure 9.4–2) is started and a manual damper opened to provide filtered exhaust from the module unit hood.

9.4.11.3 Safety Evaluation

The two hydrogen recombiner package systems and the ductwork associated with the post-accident sample module exhaust system up to and including isolation damper 3HVR*DMP60 (refer to Figure 9.4.2, Sheet 5) are QA and Seismic Category I. The hydrogen recombiner skid mounted package systems are located within a Seismic Category I structure, which is designed for missile, earthquake, tornado, and flood protection. The hydrogen recombiner ventilation ductwork, associated components and QA Category I portions of the hydrogen recombiner building post-accident exhaust systems are also seismically supported.

To preclude post-accident containment leakage into the hydrogen recombiner building, the boundary of the SLCRS (Section 6.2.3) extends to the annular space between the containment and the hydrogen recombiner building. This area has been provided with air tight seals to allow proper functioning of the SLCRS.

The electrical components (electro-hydraulic dampers, fans, and radiation elements) of the hydrogen recombiner ventilation system are powered from the Class IE power supply to maintain the function of the system during a postulated accident. In the event of a loss of electrical power, the electro-hydraulic operated dampers are additionally designed to fail close. A manual control switch with position indicating lights is provided on the ventilation panel (VP-1) for each train of these dampers allowing manual operation for building isolation from the main control room.

Redundancy is designed into the system (separate ventilation loops for each of the redundant hydrogen recombiner package systems) to assure that no single failure results in the loss of function of both systems. Three hour rated fire dampers are located where ductwork runs from one room into another. This minimizes the adverse effects of a fire to systems and components important to safety.

Each hydrogen recombiner package system has a radiation element in its related exhaust ductwork to detect airborne radiation in the event of a rupture in the process piping loop. Upon signal from a radiation monitor, the supply and exhaust MODs automatically close and the hydrogen recombiner package system shuts down.

9.4.11.4 Inspection and Test Requirements

The hydrogen recombiner building HVAC systems were air-leak tested, pressure tested, air-balance tested, adjusted and inspected for proper installation of ductwork, components, and supports. The HVAC equipment room ventilation system, the control room air conditioning system and the electric unit heaters are operated when required during normal plant operation; therefore, no periodic testing is necessary.

9.4.11.5 Instrumentation Requirements

The hydrogen recombiner control room air conditioning system thermostatically operates to maintain the control room high temperature at approximately 75°F. Two wall mounted electric heaters, each controlled by its own thermostat maintain the control room low temperature at approximately 67°F. The hydrogen recombiner HVAC equipment room ventilation system thermostatically operates to maintain the equipment room below 104°F.

The hydrogen recombiner ventilation inlet and outlet isolation dampers have manual controls and indicator lights located in the Main Control Room on the main HVAC Panel VP-1. Upon receiving a high radiation signal from its exhaust ventilation radiation monitor, the corresponding isolation dampers are closed automatically, and the recombiner package system shuts down. Through limit switches, the inlet and exhaust MODs are interlocked with the hydrogen recombiner package system allowing the recombiner system to start.

9.4.12 MISCELLANEOUS BUILDING HEATING AND VENTILATION

This section includes the following systems:

1. Service building ventilation and air conditioning (Figure 9.4–6)

2. Auxiliary boiler room ventilation (Figure 9.4–7)

3. Hot water heating (Figure 9.4–8)

4. Hot water preheating (Figure 9.4–8)

All of these systems are nonnuclear safety related.

9.4.12.1 Design Bases

9.4.12.1.1 Service Building Ventilation and air conditioning System

The service building ventilation and air conditioning system provides a suitable environment for personnel and equipment.

The required flow rates for the various portions of the service building ventilation are based on heat dissipation from equipment, dilution and removal of toxic vapors, or laboratory hood ventilation air requirements, whichever is greatest.

Portions of the service building ventilation are designed to control airborne contaminants generated in potentially contaminated areas (PCA). All service building PCA ventilation exhausts are designed to be separate from those exhausts that serve clean areas.

The outdoor air design temperature is 86°F in the summer and 0°F in the winter.

The inside air-conditioned spaces are designed for a temperature of 75°F in both summer and winter. Non air-conditioned spaces where electrical equipment is located, such as the switchgear room, are designed for a temperature of 104°F in summer and 65°F in winter.

Service building non air-conditioned spaces, such as the machine shop are designed for a maximum temperature of 95°F in summer and a minimum of 65°F in winter.

Air flow provided for dilution of toxic vapors is sufficient to provide not less than 10 air changes per hour in all areas within the service building. Laboratory hoods are designed to have minimum face velocities of 50 to 125 feet per minute to ensure that toxic vapors do not escape from the laboratory hoods into the building area.

9.4.12.1.2 Auxiliary Boiler Room Ventilation System

The auxiliary boiler room ventilation system provides a suitable environment for personnel and equipment.

The outdoor air design temperature is 86°F in the summer and 0°F in winter.

The auxiliary boiler building ventilation system is designed for a maximum temperature of 104°F.

9.4.12.1.3 Hot Water Heating

The hot water heating system supplies hot water throughout the plant to provide space heating.

The system provides a supply of 270°F hot water to the various heating units, with a return temperature of 190°F.

9.4.12.1.4 Hot Water Preheating System

The hot water preheating system supplies hot water to various ventilation units for tempering outdoor air before it is heated and distributed in the building.

The system uses water from the hot water heating system and a three-way control valve to regulate the temperature of water supplied to the preheating coils.

9.4.12.2 System Description

9.4.12.2.1 Service Building Ventilation and air conditioning System

The service building ventilation and air conditioning system (Figure 9.4–6) consists of seven subsystems:

1. Clean area air conditioning subsystem.

2. Potentially contaminated area (PCA) air conditioning subsystem.

3. Clean locker, shower and instrument repair shop ventilation subsystem.

4. Switchgear ventilation subsystem.

5. Shop area ventilation subsystem.

6. Mechanical equipment room ventilation subsystem.

7. Metrology Lab Air Conditioning System.

The subsystems are arranged so that PCA exhaust air fans serving a given area are electrically interlocked with the supply air fans serving the same area to be sure that air is not supplied to an area unless air is also being exhausted from that area. In clean areas, the exhaust air fans do not operate until the associated supply air fans are in operation.

Clean Area Air Conditioning Subsystem

The clean area air conditioning unit serves the clean area office cubicles, the instrument supervisor and instrument foreman offices, instrument repair room, storage room, kitchen, lunch room, first aid, toilet and janitor room areas. This system operates on a recirculation basis. The intake air damper and the exhaust and bypass air dampers modulate to maintain a minimum mixed air temperature supplied to the air conditioning unit. The air conditioning unit heats or cools the supply air to maintain required space temperature through temperature controllers located in the conditioned spaces. The outside air temperature sensing element regulates the operation of the hot water heating coil valve. From the kitchen area, air is exhausted by a locally controlled rooftop ventilator.

Potentially Contaminated Area (PCA) Air Conditioning Subsystem

The PCA air conditioning unit serves the radiation protection areas, the calibration room, the count room, the radioactive chemistry laboratory, the chemist offices, and the PCA storage area (el 24 feet 6 inches). The air conditioning unit heats or cools the supply air to maintain space temperature through temperature controllers located in the conditioned spaces. The outside air temperature in conjunction with the hot deck temperature regulates the operation of the hot water reheat coil valve. In the radioactive chemistry laboratory, relative humidity is maintained through a moisture controller with the aid of an electric duct heater and necessary control instrumentation. A negative pressure is maintained in the conditioned space, served by this air conditioning unit and designated as a potentially contaminated area (PCA). All the exhausts from the PCA are filtered through HEPA filters and exhausted by two centrifugal exhaust fans to the vent in the reactor plant ventilation system.

Clean Locker and Shower Ventilation Subsystem

A heating and ventilating unit serves the clean locker rooms, washrooms, corridors, men's and women's rooms. The instrument repair shop is equipped with an oil bath, which has a wall exhaust fan. This exhaust fan operates only when the oil bath is in use. The heating and ventilating unit maintains space temperature through temperature controllers located in the conditioned spaces. The temperature controllers modulate the hot and cold deck dampers to maintain the proper supply air temperature. The outside air temperature sensing element regulates the operation of the hot water reheat-coil valve, through proper instrumentation. An axial flow exhaust fan, equipped with a back-draft damper, exhausts all the air from this system.

Switchgear Ventilation Subsystem

The switchgear room is ventilated by two 50 percent capacity supply fans equipped with back-draft dampers and two 50 percent capacity exhaust fans also equipped with back-draft dampers. This system operates on a recirculation basis. The room temperature controller maintains the room temperature by modulating the intake air damper, the exhaust, and bypass air dampers. The switchgear room ductwork contains fire dampers at required locations to isolate the room in the event of combustion hazards. Air transferred to and exhausted from the service building elevator and electrical tunnel areas for ventilation purposes is replaced by dry media prefiltered air from outside the subsystem.

Shop Area Ventilation Subsystem

Service building shop area ventilation is furnished by a 100 percent capacity axial flow supply fan, a 100 percent capacity axial flow exhaust fan, and two centrifugal fans. One of the centrifugal fans exhausts the breaker repair facility. The other centrifugal fan exhausts the flammable materials storage area, which is isolated by fire dampers in the event of fire hazards.

The shop area supply air is filtered by a dry media prefilter and heated by a hot water heating coil when called for by the temperature controller in the room. This system operates on a recirculation basis. A preset temperature controller placed before the prefilter and the heating coil modulates the intake air damper, the exhaust air damper, and the recirculation air dampers.

Mechanical Equipment Room Ventilation Subsystem

The mechanical equipment room is ventilated by a 100 percent capacity axial flow fan and exhausted by a 100 percent capacity axial flow fan. The supply air is filtered by a dry media prefilter and heated by a hot water heating coil, when called for by the temperature controller in the room. The system also operates on a recirculation basis. A preset temperature controller, placed before the prefilter and the heating coil, modulates the intake air damper, the exhaust air damper, and the recirculation air damper.

Metrology Lab

The Metrology Lab is served by a water source heat pump for both summer cooling and winter heating. The system operated on a recirculation basis with fresh air makeup coming from the Clean Locker and Shower Ventilation Subsystem. The unit maintains the desired temperature by means of a thermostat located in the room. The source of cooling/heating water is the Component Cooling System (CCP).

9.4.12.2.2 Auxiliary Boiler Room Ventilation

The auxiliary boiler room ventilation system (Figure 9.4–7) serves the entire auxiliary boiler building. The system contains two 50 percent capacity supply fans equipped with silencers and two 50 percent capacity exhaust fans also equipped with silencers. This system operates on a recirculation basis and uses 100 percent outdoor air for cooling. The room temperature controller maintains the room temperature by modulating the intake air damper, the exhaust air damper, and the recirculation air dampers.

9.4.12.2.3 Hot Water Heating System

The hot water heating system (Figure 9.4–8) supplies hot water for heating the turbine building and auxiliary bay, warehouse, service building, auxiliary building, fuel building, waste disposal building, main steam valve building, auxiliary boiler room, and condensate polishing enclosure. The system also supplies hot water to the hot water preheat system and condensate polishing enclosure.

The major components of this closed loop system include two 60 percent capacity steam to water heat exchangers, two 100 percent capacity winter water circulating pumps, one 100 percent capacity summer water circulating pump, and one hot water heating makeup pump. An air separator is included in the return lines to the pumps. One expansion tank in the return line accommodates water expansion from cold start to system operating temperature. Nitrogen charging of the expansion tank provides system pressurization to maintain system pressure above that of the auxiliary steam system.

The hot water heating system has two operating modes depending on outside temperature. When the outside temperature drops below 50°F, it is in the winter mode. Hot water is channeled from the heat exchanger to unit heaters in the various buildings and to the hot water preheating system. When the outside temperature rises above 55°F, the system is automatically transferred to the summer mode and circulation of water is passed through the hot water heat exchangers and to various air conditioning and ventilation units.

Pressure switches are installed to allow isolation of hot water heating system supply lines to the auxiliary and fuel building in case of a high-energy break in these areas. (See Table 3.6–5.)

9.4.12.2.4 Hot Water Preheating

The hot water preheating system (Figure 9.4–8) supplies heated water to the heating coils of the following units:

1. Auxiliary building ventilation units.
2. Clean locker ventilation units.
3. Reactor containment purge units.
4. Waste disposal/fuel building ventilation units.
5. Potentially contaminated area air conditioning unit.

The hot water preheating system consists of two 100 percent capacity circulating pumps and a temperature control valve. The temperature valve mixes return water with hot water from the hot water heating system to control the preheating water temperature.

The hot water preheating mixing valve is modulated by a temperature indicating controller.

9.4.12.3 Safety Evaluation

The ventilation and air conditioning systems serving the service building, and auxiliary boiler room are non safety related systems and are not required to perform any safety function.

The hot water heating and hot water preheating systems are also non safety related systems. These systems operate at a pressure above that of the auxiliary steam system, so that in the event of a tube leak in the steam to water heat exchanger, water flows out of the heating system. This prevents any possible contamination within the auxiliary steam system from entering the hot water heating system.

9.4.12.4 Inspection and Testing Requirements

The ventilation and air conditioning systems serving the service building, office building, and auxiliary boiler room and the hot water heating systems were inspected during and after installation. These systems were carefully tested and balanced to be sure that each space or area receives its design air quantity or heating requirements.

The ventilation systems and heating systems are normally in operation. Therefore, they do not require any periodic testing. Visual inspections are conducted following any regular system maintenance to confirm normal system operation.

9.4.12.5 Instrumentation Requirements

Service Building Ventilation

The service building ventilation system operating parameters are monitored, indicated, and controlled, locally or remotely as follows. Unless stated otherwise the following instruments and controls are located on the service building ventilation panel:

1. Control switches with indicator lights are provided for manual operation of the switchgear room and tunnel supply fans. The supply fans are stopped automatically by a CO_2 release equipment shutdown signal. The switchgear room ventilation exhaust fans are interlocked to start and stop with the associated supply fan.

2. A temperature controller located in the switchgear room is utilized to modulate the switchgear room ventilated inlet, outlet, and recirculation dampers when either switchgear room and tunnel supply fan is running. When both supply fans are stopped, or when the CO_2 purge switch is placed in "purge," the inlet and outlet dampers open and the recirculation damper closes.

3. The electrical tunnels inlet dampers are interlocked to open when either switchgear room and tunnel supply fan is running. The inlet dampers are closed when both supply fans are stopped. When a CO_2 release equipment shutdown signal exists for an individual tunnel, only the inlet damper to that tunnel closes. Position indicator lights are provided for both dampers.

4. A thermostat located in the elevator shaft controls the service building elevator exhaust fan. The fan is stopped automatically by a CO_2 release equipment shutdown signal.

5. The service building air handling unit is provided with a control switch and indicator lights. The air-handling unit inlet damper is opened and closed by the control switch and the air handling unit is interlocked to start when the inlet damper is open and stop when the inlet damper is closed. The inlet damper closes automatically when the air entering the hot water preheater is less than 35°F to protect against freezing.

6. A temperature controller is utilized to modulate the hot water heating valve. Outside temperature is compared to the hot deck air temperature; the delta is the controller input signal.

7. Local temperature controllers are used to modulate hot and cold deck air dampers. The service building clean locker area exhaust fan is interlocked to start and stop with the service building air handling unit. Indicator lights are provided on the service building ventilation panel.

8. The equipment room supply fan has a control switch and indicator lights for manual operation. The exhaust fan is provided with indicator lights and is interlocked to start and stop with the supply fan. To protect the hot water heater from freezing, the supply fan stops automatically if the hot water heater outlet temperature drops to 40°F.

9. A direct sensing temperature controller is utilized to modulate the equipment room inlet, outlet, and recirculation dampers to maintain mixed inlet and recirculated air temperature above 50°F provided when the equipment room supply fan is running.

10. The hot water heating temperature valve is modulated by a thermostat located in the equipment room. The valve is interlocked to open when the supply fan is stopped.

11. The service building shop supply fan is provided with a control switch and indicator lights for manual operation. If the hot water heater outlet temperature drops to 40°F, the fan stops automatically to protect the hot water heater from freezing.

12. The service building machine shop exhaust fan, the service building welding shop exhaust fan, and the service building flammable materials storage area exhaust fan are interlocked to start and stop with the service building shop supply fan. The exhaust fans are all provided with indicator lights.

13. A direct sensing temperature controller is utilized to modulate the service building shop inlet, outlet, and recirculation dampers to maintain mixed air (inlet and recirculation) temperature above a preset temperature provided the service building shop supply fan is operating.

14. The potentially contaminated area (PCA) air conditioning unit is interlocked to start when the PCA A/C unit inlet damper is open and stop when the inlet damper is closed. The inlet damper will open automatically when the PCA exhaust and radiation chemistry laboratory exhaust fans are running. The exhaust fans stop automatically if the hot water preheater temperature drops to 35°F. Indicating lights are provided on the inlet damper, exhaust fans, and air conditioning unit.

15. All service building filters are provided with a first out annunciator that alarms when the differential pressure across the filter is high. A local differential pressure indicator is provided at each filter to indicate a dirty or clogged filter.

16. First out annunciators are provided to alarm when the inlet air temperature drops to 35°F for heating coils in 3HVE-HVU1, 3HVL-ACU1 and 3HVL-ACU2 or the outlet air temperature drops to 40°F for heating coils 3HVE-CH1 and 3HVE-CH2.

17. Any annunciator that alarms on the service building ventilation panel causes the service building ventilation system trouble annunciator on the main heating and

ventilation panel in the control room to alarm. When the CO_2 purge switch is placed in “purge,” the service building ventilation system trouble annunciator alarms on the main heating and ventilation panel.

Hot Water Preheating System

The hot water preheating system operating parameters are monitored, indicated, and controlled, locally or remotely as follows. Unless stated otherwise, all controls are located on the hot water heating panel:

Control switches and indicator lights are provided for the hot water preheating circulating pumps. The hot water preheating circulating pumps are interlocked so that one hot water winter heating pump must be running to start a hot water preheating circulating pump.

Annunciators are provided to alarm when the following conditions exist:

1. Hot water preheating circulation pumps discharge pressure Low.

2. Hot water preheating return water temperature High.

A temperature indicating controller is utilized to modulate the hot water preheating mixing valve. Outside air temperature is compared with the preheating circulating pump discharge temperature; the delta is used as an input to the controller.

A hot water heating system trouble annunciator is alarmed on the main control board when an alarm condition exists on the hot water heating panel.

Hot Water Heating

The hot water heating system operating parameters are monitored, indicated, and controlled, locally or remotely as follows:

The main control board has annunciators for:

1. 480 volt bus undervoltage

2. Load center loss of control power

3. Hot water heating system trouble

4. Hot water expansion tank level Low - Low

The main control board rear has status windows for the service building bus undervoltage and loss of control power.

The following instruments and controls are located on the hot water heating panel:

Controls

1. START-AUTO-STOP control switch with indicating lights for the winter water circulating pumps.

2. RUN-AUTO-OFF control switch with indicating lights for summer water circulating pump and the hot water heating makeup pump.

3. SUMMER-AUTO-WINTER mode switch with indicating lights for the summer/winter changeover valve.

4. OPEN-AUTO-CLOSE control switch with indicating lights for the hot water expansion tank level valve.

Annunciators

1. Winter water circulating pump discharge pressure Low.

2. Summer water circulating pump discharge pressure Low.

3. Winter water circulating pump auto trip/overcurrent.

4. Hot water heating water temperature High/Low.

5. Hot water expansion tank pressure High/Low.

6. Hot water expansion tank level High/Low.

Indicators

1. Hot water expansion tank level.

2. Outside air temperature.

A controller with auto-manual feature and indication utilized for the steam-to-water heat exchanger summer and winter temperature valves is located on the hot water heating panel.

Indicating lights for the winter water circulating pump operation are provided at the switch gear.

The following parameters are monitored by the plant computer:

1. Winter water circulating pumps breaker position.

2. Winter water circulating pump autotrip.

Auxiliary Boiler Room Ventilation

The auxiliary boiler room ventilation supply fans have control switches with indicator lights located on the auxiliary boiler room ventilation panel. In the automatic mode, the B supply starts automatically when room temperature reaches 75°F; the A fan starts when room temperature reaches 85°F. Both fans will maintain room temperature at a maximum of 105°F.

The exhaust fans are interlocked to start and stop with the supply fans.

A temperature controller for each train is utilized to modulate the inlet, outlet, and recirculation dampers to maintain supply fan discharge temperature at a minimum preset value provided the supply fan is running. The supply fans discharge temperature is indicated on the auxiliary boiler room ventilation panel.

9.4.13 TECHNICAL SUPPORT CENTER HEATING, VENTILATION, AIR CONDITIONING, AND FILTRATION SYSTEM

The technical support center (TSC) is the on site facility from which technical direction can be administered, to relieve plant operators from peripheral duties during an emergency, by up to 20 licensee and NRC personnel. Capacity in the TSC may exceed 20 people provided atmospheric monitoring is conducted. The primary functions of TSC heating, ventilation, air conditioning, and filtration (HVACF) system are to provide a suitable environment for maintaining proper equipment operation, to provide for radiological protection to personnel occupying the TSC, and to provide storage of plant records.

A portable radiation monitor located within the TSC office area detects and responds to the presence of radioactivity.

The technical support center HVACF system is classified as nonnuclear safety related and non-Seismic.

9.4.13.1 Design Bases

The technical support center HVACF system design is based on the following criteria:

1. American National Standard, ANSI N509-1980, Nuclear Power Plant Air Cleaning Units and Components.

2. American National Standard, ANSI N510-1980, Testing of Nuclear Air Cleaning Systems.

3. System is designated as Nonnuclear safety as described in FSAR Section 3.2.

4. Regulatory Guide 1.52, Revision 2 (for carbon media).

5. The range of indoor design temperatures during normal and abnormal plant conditions is as follows:

Area	**Maximum Space Temperature**	**Minimum Space Temperature**
TSC Office	75°F	75°F
TSC Lavatory	85°F	65°F
TSC Mechanical Equipment Penthouse	104°F	40°F

6. The range of outdoor temperatures are as follows:

Summer design temperature	- 86°F dry bulb - 75°F wet bulb
Winter design temperature	- 0°F dry bulb
Outdoor daily range of dry bulb temperatures	- 16°F

7. Supplement 1 to NUREG-0737, Requirements for Emergency Response Capability.

8. Radiation exposure to any person occupying the TSC does not exceed 5 rem TEDE as a result of a design basis accident.

9.4.13.2 System Description

The technical support center HVACF system is shown on Figure 9.4–9. The system is comprised of the following subsystems:

1. TSC heating, ventilation, and air conditioning.

2. TSC filtration.

3. TSC lavatory exhaust.

The system consists of a split-system air conditioning unit, duct-mounted electric heating coil, motor-operated dampers, and associated duct work and accessories. The air is passed through a disposable type impingement filter, direct expansion (DX) coil, and blower before it enters the conditioned space. The majority of air is recirculated and is mixed with an adequate quantity of outside makeup air during normal plant operation. The system operates automatically and is controlled by a thermostat located in the TSC office area.

During the heating season when the TSC air space temperature is lower than a predetermined setpoint, the office area temperature indicating controller activates the electric coils mounted in the duct to provide heated air to TSC office areas and the mechanical equipment penthouse.

Upon receipt of a control building isolation (CBI) signal, which is initiated by any of the conditions listed in Section 9.4.0 motor-operated dampers modulate to their respective positions to allow for building isolation. The TSC charcoal filtration assembly starts to operate in a filtered recirculation mode (2,000 cfm of recirculated air for 30 minutes) and the lavatory exhaust fan shuts down.

The filtration assembly fan draws 2,000 cfm through a disposable type impingement prefilter, an upstream HEPA filter, a 95 percent efficient charcoal adsorber, and a downstream HEPA filter, and discharge the air to the intake of the air conditioning unit.

Thirty minutes following the isolation signal, the solenoid-operated dampers modulate to provide 100 cfm outside air and 1,900 cfm recirculation air into the TSC charcoal filtration assembly which is discharged to the intake of the air conditioning unit.

The mixture of filtered air and recirculation air is drawn through the air conditioning unit to provide conditioned air for breathing and a positive pressure in TSC air space to minimize infiltration of airborne radioactivity.

9.4.13.3 Safety Evaluation

The technical support center HVACF system does not have a safety related function, and its failure does not affect operation of any other safety related system or component. The HVACF system can operate during or after a postulated accident and can be operated during normal plant conditions.

The ventilation electrical and control circuitry is not designed to meet Class 1E, single failure or seismic qualification requirements, but is powered by the normal AC power supply and, through a transfer switch, is supplied with reliable auxiliary power from the site security diesel during loss of off site AC power.

9.4.13.4 Inspection and Testing Requirements

The TSC air conditioning and ventilation system was field tested and inspected for air balance and completeness of installation.

HEPA filters and charcoal adsorbers are procured to the performance requirements of ANSI N509-1980, Section 5.1 and Table 5.1, respectively, as stated in Regulatory Guide 1.52, Paragraphs 3.d and 5.d.

The filter housing, HEPA filter bank, and charcoal adsorber bank are tested to the inplace leakage testing requirements of ANSI N510-1980. Test canisters are provided to allow for periodic removal of used activated carbon samples for laboratory testing to the criteria of Regulatory Guide 1.52, Table 2.

Compliance with these testing requirements allows the assigned decontamination efficiencies listed in Table 2 of Regulatory Guide 1.52, Revision 2, for 95 percent efficiency of particulate and gaseous iodine removal, to be applied in the dose analysis performed in support of NUREG-0737 as discussed in Section 12.3.1.

All filters (prefilter, HEPA, and charcoal adsorbers) are provided with pressure differential indicating switches for visual maintenance checks to ensure replacement when setpoints indicate dirty filter conditions.

9.4.13.5 Instrumentation Requirements

A temperature switch controls the operation of the air conditioning unit and a temperature switch energizes the electric heater mounted in the duct air stream. A switch for either STOP or START modes of operation for the air conditioner fan, and status indication lights, are provided on a local panel.

The TSC is automatically isolated from the outside atmosphere upon receipt of a CBI signal with modulation of motor-operated dampers. The dampers are provided with indication lights on a local panel for OPEN/CLOSED status indication.

The filtration assembly is provided with locally mounted OFF-AUTO control switches and Unit OFF-RUNNING status indication lights on a control panel located in the office area. In the AUTO mode, the filtration fan starts by closure of a motor-operated isolation damper. Pressure differential indicating switches are provided locally for filter condition surveillance. A fire detector for indication of ignition of the carbon media alarms locally and in the control building control room.

9.4.14 REFERENCES FOR SECTION 9.4.0

9.4-1 American Society of Heating, Refrigeration, and air conditioning Engineers (ASHRAE), 1972 Handbook of Fundamentals.

TABLE 9.4–1 INDOOR DESIGN TEMPERATURES FOR CONTROL BUILDING

Area	Dry Bulb Temperatures		Relative Humidity (%)
	Winter (°F)	Summer (°F)	
Control room	75	75	40-60
Instrument rack room and computer room	75	75	40-60
Switchgear areas	65	85	10-70
Battery rooms 1, 2 and 5	65	85	10-70
Chiller room	50	104	10-90
Mechanical room	50	104	10-70
Cable spreading room	50	104	10-90
Battery Room 3	55	85	10-70
Battery Room 4	60	85	10-70

TABLE 9.4–2 CONTROL BUILDING COMPONENT PERFORMANCE CHARACTERISTICS FOR AIR CONDITIONING, HEATING, COOLING, AND VENTILATION SYSTEMS

Components	Design Parameters
Switchgear Area	
Air conditioning units	
First unit (2) 3HVC*ACU4A, 4B	21,000 cfm each at 3.50 inches water gage (wg) (1)
Cooling coil	432,000 Btu/hr
Filter	90 - 95% efficiency
Second Unit (2) 3HVC*ACU3A, 3B	10,000 cfm each at 3.70 inches wg (1)
Cooling coil	210,000 Btu/hr
Filter	90 - 95% efficiency
Makeup fan (2) 3HVC*FN3A, 3B (2)	1,500 cfm each
Electric duct heater (2) 3HVC*CH2, 3	31.0 kW each
Supply air filters (2) 3HVC*FLT2, 3	55-65% efficiency, each
Purge System	
Supply fan 3HVC-FN4	4,000 cfm
Exhaust fan 3HVC-FN5	4,000 cfm
Battery Rooms	
Room 1 exhaust fan 3HVC*FN9A	450 cfm
Room 2 exhaust fan 3HVC*FN9B	750 cfm
Room 3 exhaust fan 3HVC*FN9C	400 cfm
Room 4 exhaust fan 3HVC*FN9D	750 cfm
Room 5 exhaust fan 3HVC*FN9E	650 cfm
Chiller Room	
Supply fan (2) 3HVC*FN2A, 2B	2,000 cfm each
Electric duct heater (2) 3HVC-CH1A, 1B	41 kW each
Exhaust fan (2) 3HVC*FN7A, 7B	2,000 cfm each
Supply air filter (2) 3HVC*FLT4A, 4B	55-65% efficiency, each
Instrument Rack Room and Computer Room	

TABLE 9.4–2 CONTROL BUILDING COMPONENT PERFORMANCE CHARACTERISTICS FOR AIR CONDITIONING, HEATING, COOLING, AND VENTILATION SYSTEMS (CONTINUED)

Components	Design Parameters
Humidifier 3HVC-HUM2	15 lb/hr moisture
Air conditioning unit (2) 3HVC*ACU2A, 2B	32,300 cfm each at 11.23 inches wg (1)
Cooling coil	662,500 Btu/hr
Heating coil	50 kW
Filter	90-95% efficiency
Control Room	
Air-conditioning unit (2) 3HVC*ACU1A, 1B	21,725 cfm each at 5.95 inches wg (1)
Cooling coil	551,000 Btu/hr
Heating coil	70 kW
Filter	90-95% efficiency
Humidifier 3HVC-HUM1	55 lb/hr of water
Pressurizing air storage tank (9)	23.27 cubic feet (liquid) each
3HVC*TKIA, 1B, 1C, 1D, 1E, 1F, 1G, 1H, 1J	
Piping	2,450 psig
Valve	2,450 psig
Toilet and kitchenette exhaust fan 3HVC-FN6	595 cfm
Emergency ventilation filter unit (2) 3HVC*FLT1A, 1B	1,225 cfm clean / 1,000 cfm dirty
Moisture separator	99% efficiency at 10 to 100μ)
HEPA (2)	99.97% efficiency DOP
Charcoal	99.99% efficiency (iodine adsorption)
Prefilter	80% efficiency NBS
Heater	9.4 kW
Fan 3HVC*FN1A, 1B	1,070 cfm at 12.6 inches wg
Control Building	
Isolation Valves (3)	
Exhaust 3HVC*AOV22, 23	4,000 cfm

TABLE 9.4–2 CONTROL BUILDING COMPONENT PERFORMANCE CHARACTERISTICS FOR AIR CONDITIONING, HEATING, COOLING, AND VENTILATION SYSTEMS (CONTINUED)

Components	Design Parameters
Exhaust 3HVC*AOV20, 21	595 cfm
Chilled water pump (2) 3HVK*PIA, 1B	450 gpm each
Isolation Dampers (4)	
Supply 3HVC*AOD27A, B	
Water chiller (2) 3HVK*CHL1A, 1B	250 tons each

NOTES:

1. Units in inches water gage (wg) at static pressure (sp).
2. 3HVC*FN3A (3B) are axial flow fan assemblies, each consisting of two axial flow fans installed in series (i.e. 3HVC*FN3A1 & 3HVC*FN3A2, 3HVC*FN3B1 and 3HVC*FN3B2) with each fan driven by its own motor.
3. Design closure time for all valves is 3 seconds under maximum of 5 in wg pressure differential.
4. Design closure time for 3HVC*AOD27A, B is 6 seconds.

TABLE 9.4–3 DESIGN DATA FOR MAJOR COMPONENTS IN FUEL BUILDING VENTILATION SYSTEM

Fuel Building Filter Bank Exhaust Fans	Approximate Design Parameters (NOTE 1)
Equipment mark number	3HVR*FN10A, 10B
Quantity	2 (NOTE 2)
Specification number	2170.430-140
Manufacturer	Buffalo Forge Co.
Type	Vane axial
Rated Capacity (cfm)	30,000
Fluid	Air
Design temperature (°F)	65-104
Operating temperature (°F)	65-104
Drive	Direct
Total pressure (in wg)	16.5 (NOTE 3)
Motor data:	
Type	TEAO
Horsepower	2 at 75 hp each
Volts/phases/frequency	460/3/60
Speed (rpm)	3600
Insulation class	H
Weight (lb.)	2800
Reference drawing	EB-45G
Location	Auxiliary building
Fuel Building Filter Bank Bypass Fan	Approximate Design Parameters (NOTE 1)
Equipment mark number	3HVR-FN9
Quantity	1
Specification number	2138.430-007
Manufacturer	Joy Manufacturing Co.
Type	Vane axial
Capacity (cfm)	41,360
Fluid	Air
Design temperature (°F)	65-104
Operating temperature (°F)	65-104
Drive	Direct

TABLE 9.4–3 DESIGN DATA FOR MAJOR COMPONENTS IN FUEL BUILDING VENTILATION SYSTEM (CONTINUED)

Total pressure (in wg)	5.5 (@ 46,400 cfm)
Motor data:	
Type	TEAO
Horsepower (nominal)	75
Volts/phases/frequency	460/3/60
Speed (rpm)	1770
Insulation class	F
Weight (lb.)	1,857
Reference drawing	EB-45L, EB-45M
Location	Auxiliary building
Fuel Building Filtration Units	Approximate Design Parameters (NOTE 1)
Equipment mark number	3HVR*FLT 2A/2B
Quantity	2
Specification number	2170.430-065
Total capacity (cfm/unit)	20,680 (note 1)
Filter pressure drop (in wg)	9.86 (note 3)
Prefilter:	
Efficiency (percent) (ASHRAE)	80-90
Rated capacity (cfm)	20,680
Pressure drop, clean/changeout (in wg)	0.55/1.00 in wg (NOTE 3)
HEPA Filter:	
Rated capacity (cfm)	20,680
Pressure drop, clean/changeout (in wg)	1.30/2.00 in wg (NOTE 3)
Charcoal adsorber:	
Rated capacity (cfm)	20,680
Pressure drop, clean/changeout (in wg)	2.81 in wg (NOTE 3)
Reference flow diagram	P&ID EM-148C
Location	Auxiliary building

TABLE 9.4–3 DESIGN DATA FOR MAJOR COMPONENTS IN FUEL BUILDING VENTILATION SYSTEM (CONTINUED)

Fuel Building Heating and Ventilating Supply Units	Approximate Design Parameters (NOTE 1)
Equipment mark number	3HVR-HVU3A, 3B, 3C
Quantity	3
Specification number	2138.430-143
Manufacturer	Buffalo Forge Co.
Performance at specified conditions:	
Fan capacity (cfm)	34,000
Suction pressure (in wg)	4.0
Rotation/rpm	1,072
Brake horsepower	38.6
Heating coils (preheat/reheat):	
Capacity (MBh)	2070/724
Face area (sq. ft.)	41.4g/27.5
Rows furnished	2/1
Pressure drop (ft. of water)	3.4/0.7
Filters:	
Type	Continental “Cono 45” or equivalent
Operating weight, complete unit (lb.)	7,750
Motor data:	
Horsepower	50
Full load (rpm)	1,800
Enclosure	ODP
Reference drawing	EB-77Q
Location Waste Disposal Building	Waste Disposal Building

NOTES:

1. Some values are based on rated flow of 30,000 cfm, not the design flow of 20,680 cfm reflected on the P&ID and startup testing.
2. 3HVR*FN10A (10 B) are axial flow fan assemblies, each consisting of two axial flow fans installed in series with each fan driven by its own motor (Ref: P&ID EM-148C).
3. This value is based on vendors rated flow of 30,000 cfm not the actual startup test and P&ID value of 20,680 cfm.

TABLE 9.4–4 AUXILIARY BUILDING VENTILATION SYSTEM PRINCIPAL COMPONENTS AND DESIGN PARAMETERS

Components	Design Parameters
Auxiliary Building Heating and Ventilating Supply Units	
Number of units	2
Number of fans per unit	1
Capacity, each (cfm)	33,000/31,550
Total pressure (in wg)	3.5/3.6
Motor (hp)	30
Auxiliary Building Ventilation Exhaust Fans	
Number of fans	1/1
Capacity (cfm)	50,000/22,000
Total pressure (in wg)	5.7/4.9
Motor (hp)	75/30
Auxiliary Building Filtration Units and Fans	
Number of units	2
Number of fans per unit	1
Capacity, each (cfm)	30,000
Total pressure (in wg)	10.5
Motor (hp)	75
Motor Control Center, Rod Control, and Cable Vault Air conditioning Units	
Number of units	2
Number of fans per unit	1
Capacity, each (cfm)	26,000
Total pressure (in wg)	9.0
Motor (hp)	50
Charging Pump, Component Cooling Pump, and Heat Exchanger Areas Supply Fans	
Number of fans	2
Capacity, each (cfm)	27,000
Total pressure (in wg)	6.5

TABLE 9.4–4 AUXILIARY BUILDING VENTILATION SYSTEM PRINCIPAL COMPONENTS AND DESIGN PARAMETERS (CONTINUED)

Components	Design Parameters
Motor (hp)	40
Charging Pump, Component Cooling Pump, and Heat Exchanger Areas Exhaust Fans	
Number of fans	2
Capacity, each (cfm)	30,000
Total pressure (in wg)	6.5
Motor (hp)	60

TABLE 9.4–5 TURBINE BUILDING VENTILATION SYSTEM PRINCIPAL COMPONENTS AND APPROXIMATE PARAMETERS

Component Title	Quantity	Fan Capacity (cfm) Each	Static Pressure (in wg)	Motor (Hp) Each
Turbine building supply fans	4	165,000	4.3	200
Turbine building exhaust fans	12	60,000	2.6	50
Turbine building transfer fans	6	70,000	2.2	40
Lube oil room exhaust fans	1	2,000	1.42	1
	1	2,000	0.42	1
Elevator machine room exhaust fan	1	500	0.125	0.125
Sample sink exhaust fan	1	1,700	2.75	2
Welding area exhaust fan	1	5,900	0.45	5
Maintenance toilet area exhaust fan	1	450	0.125	0.08
Condensate polishing area supply fan	1	10,400	1.6	7.5
Condensate polishing area exhaust fan	1	10,400	2.1	7.5
Battery room No. 6 supply fan	1	1,200	1.75	2

TABLE 9.4–6 ENGINEERED SAFETY FEATURES BUILDING PRINCIPAL COMPONENTS WITH APPROXIMATE DESIGN PARAMETERS

Fans	Qty	Type	Capacity (cfm)	Design Parameters*		Remarks
				Total Pressure (in wg)	Motor (hp)	
NORMAL VENTILATION SYSTEM COMPONENT						
Mechanical rooms supply (3HVQ-FN3) and exhaust (3HVQ-FN4) fans	2	Axial	4,000	1.9 Supply	3	Supply O.A. **4,000 cfm
				1.0 Exhaust	2	Exhaust to O.A. 4,000 cfm
Both safety injection and quench spray pump areas, residual heat removal pump and heat exchanger areas, containment recirculation pump and cooler areas, refueling water recirculation pump areas, main steam piping penetration area, turbine-driven auxiliary feedwater pump area, and both motor-driven auxiliary feedwater pump areas supply (3HVQ-FN1) and exhaust (3HVQ-FN2) fans	2	Axial	8,100	2.5 Supply	5	Supply O.A. 8,100 cfm
				2.0 Exhaust	5	Exhaust O.A. 8,100 cfm
RSS and QSS area supply (3HVQ-FN8) and exhaust (3HVQ-FN7) fans	2	Centrifugal	1,500	0.90 Supply	1	Supply from refueling pumps area exhaust to refueling pump area
				0.75 Exhaust	0.5	
Emergency Ventilation System Component						
Mechanical rooms A, B, C, and D, both motor-driven auxiliary feedwater pump areas and the turbine-driven auxiliary feedwater pump area supply (3HVQ*FN5A/5B) and exhaust (3HVQ*FN6A / 6B) fans	2	Axial	20,000	4.5 Supply	20	Supply O.A. from 20,000 to 0 cfm
	2	Axial	20,000	3.5 Exhaust	15	Exhaust to O.A. from 20,000 to 0 cfm

* Design parameters are based on corresponding equipment specification and vendor drawings.

** Outside air.

A/C	Qty.	Type	Capacity (cfm)	Total Static Pressure (in wg)	Total Refrigerant Load (Btu)	Fan (hp)	Motor (hp)	Condenser Cooling Media	Refrigerants
COMPONENT									
Safety injection and quench spray pump area, residual heat removal pump and heat exchanger areas ventilation	2	Self-contained air conditioning units (3HVQ*ACU1 A/1B)	7,600	4.1	392,144	7.5	40	Service water at 80°F	R-22
Containment recirculation pump and cooler areas ventilation	2	Self-contained air conditioning units (3HVQ*ACU2 A/2B)	7,600	4.1	392,144	7.5	40	Service water at 80°F	R-22

TABLE 9.4–7 ENGINEERED SAFETY FEATURES BUILDING VENTILATION SYSTEM CONSEQUENCES OF COMPONENT FAILURES

Components	Malfunctions	Comments and Consequences
The quench Spray Pump, Safety Injection Pump, Residual Heat Removal Pump and Heat Exchanger Ventilation System, (3HVQ*ACW5A/B) Containment Recirculating Pumps and Cooler Ventilation System (Figure 9.4–4) (3HVQ*QCW52A/2B)		
Air conditioning unit casing	Casing leakage, air bypass cooling coil	Partial loss of cooling; redundant unit is available for cooling.
Air filter	Excessive dust loading, reduced airflow	Partial loss of cooling; redundant air conditioning is available for cooling.
Fan	Failure to operate	Redundant unit is available.
Cooling coil	Tube leakage	Partial loss of cooling, redundant unit is available for cooling.
Compressor	Failure to operate	Redundant unit is available.
Condenser	Tube leakage	Partial loss of cooling; redundant unit is available for cooling.
Regulating valve	Failure to operate	Redundant unit is available.
Ductwork	Duct leakage	Partial loss of ventilation, the rooms are served by supply and return systems. Should air leakage occur, adequate airflow is maintained in the rooms due to pressure differential created by undamaged duct.
Auxiliary Feedwater Pump Area Ventilation System (SUPPLY 3HVQ*FN5A/5B, EXHAUST 3HVQ*FN6A/6B) (Figure 9.4–4):		
Fan	Failure to operate	Loss of ventilation; redundant unit is available.
Damper	Failure to operate	Dampers fail to safe position. Possible partial loss of ventilation; redundant system is available.

TABLE 9.4–7 ENGINEERED SAFETY FEATURES BUILDING VENTILATION SYSTEM CONSEQUENCES OF COMPONENT FAILURES (CONTINUED)

Components	Malfunctions	Comments and Consequences
Ductwork	Duct leakage	Partial loss of ventilation; the rooms are served by supply and return systems. Should air leakage occur, adequate airflow is maintained in the rooms due to pressure differential created by undamaged duct.

TABLE 9.4–8 CONTAINMENT AIR FILTRATION SUBSYSTEM PRINCIPAL COMPONENTS DESIGN AND APPROXIMATE PARAMETERS

Components	Design Parameters	
Filtration Fans		
Number of fans	2	
Capacity, each (cfm)	12,000	
Total pressure (in wg)	9.0	
Motor, each (hp)	50	
HEPA-Charcoal Filter Banks		
Quantity	2	
Capacity, filtration each (cfm)	12,000	
Pressure drop (in wg)		
HEPA filter	1.30	new
HEPA filter	1.75	requires replacement
Charcoal adsorber	2.44	

TABLE 9.4–9 CONTAINMENT AIR RECIRCULATION SYSTEM PRINCIPAL COMPONENTS DESIGN AND APPROXIMATE PARAMETERS

Components	Design Parameters
Containment Air Recirculation Units	
Quantity	3
Number of cooling coils per unit	6
Number of fans per unit	1
Fan capacity, normal mode	143,500 cfm each with 2 fans in use
Cooling media during normal operation	Chilled water
Cooling media during loss of power	Component cooling water
Normal Fan	
Total pressure head (in wg)	6.0
Motor (hp)	250

TABLE 9.4–10 CONTAINMENT AIR RECIRCULATION SYSTEM OPERATION MODES AND APPROXIMATE DESIGN CONDITIONS OF AIR RECIRCULATION FAN COOLERS

Mode of Operation	Containment Temperature (°F)	No. of Units in Operation	Total Capacity (cfm)	Total Capacity (Btu/hr)
Normal	95	2	287,000	6,870,000
Loss of offsite power	< 135	1	160,000	2,740,000

TABLE 9.4–11 CONTAINMENT PURGE AIR SUBSYSTEM PRINCIPAL COMPONENTS AND APPROXIMATE PARAMETERS

Components	Design Parameters
Supply Units	
Number of units	2
Number of fans per unit	1
Capacity, each (cfm)	17,500
Total pressure (inches wg)	6.16
Motor (hp)	30
Exhaust Fans	
Number of fans	2
Capacity, each (cfm)	17,500
Total pressure (inches wg)	8.0
Motor, each (hp)	40

TABLE 9.4–12 CRDM COOLING SYSTEM PRINCIPAL COMPONENTS AND APPROXIMATE PARAMETERS

Component	Design Parameters
CRDM Fans	
Type	Axial
Number	3
Flow/fan (cfm) - 2 fan operation	45,000
Total pressure (inches wg)	10.67
Motor (hp)	200
Inlet Air Maximum temperature (°F)	120
Inlet Air Maximum humidity (%)	100
Head Load Maximum design (btu/hr)	3,700,000

TABLE 9.4–13 WASTE DISPOSAL BUILDING HEATING AND VENTILATION SYSTEM

Heating and Ventilating Supply Units	Design Parameters
Equipment mark number	3HVR-HVU3A, 3B, 3C
Quantity	3
Specification number	2138.430-143
Manufacturer	Buffalo Forge Co.
Performance at specified conditions:	
Fan capacity (cfm)	34,000
Fan static pressure (in wg)	4.0
Rotation/rpm	1,072
Brake horsepower	38.6
Heating coils (preheat/reheat):	
Capacity (MBh)	2070/724
Face area (square feet)	41.49/27.5
Rows furnished	2/1
Pressure drop (feet of water)	3.4/0.7
Filters:	
Type	Continental “Cono 45” or equivalent
Operating weight complete unit (lb.)	7,750
Motor data:	
Horsepower	50
Full load (rpm)	1,800
Enclosure	ODP
Reference drawing	EB-77Q
Location	Waste Disposal Building
Waste Disposal Building Exhaust Fans	Design Parameters
Equipment mark number	3HVR-FN8A/8B
Quantity	2
Specification number	2138.430-007
Manufacturer	Joy Manufacturing Co.

TABLE 9.4–13 WASTE DISPOSAL BUILDING HEATING AND VENTILATION SYSTEM (CONTINUED)

Type	Vane Axial
Capacity (cfm)	29,860
Fluid	Air
Design temperature (°F)	65-104
Operating temperature (°F)	65-104
Drive	Direct
Total pressure (in wg)	11.8
Motor data:	
Type	TEAO
Horsepower	75
Volts/phases/frequency	460/3/60
Speed (rpm)	(Later)
Insulation class	(Later)
Weight (lb)	1,988
Reference drawing	EB-45G
Location	Auxiliary building, elevation 66 feet 6 inches

FIGURE 9.4–1 (SHEETS 1-5) P&ID CONTROL BUILDING HEATING, VENTILATION AND AIR CONDITIONING

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.4–2 (SHEETS 1-6) P&ID REACTOR PLANT VENTILATION

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.4–3 (SHEETS 1-5) P&IDS TURBINE PLANT VENTILATION & ISO BUS DUCT COOLING SYSTEMS

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.4–4 (SHEETS 1-3) P&ID ESF AND MSV BUILDINGS VENTILATION

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.4–5 P&ID CONTAINMENT STRUCTURE VENTILATION

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.4–6 (SHEETS 1-3) P&ID SERVICE BUILDING VENTILATION

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.4–7 (SHEETS 1-2) P&ID AUXILIARY BOILER AND VENTILATION

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.4–8 (SHEETS 1-3) P&ID HOT WATER HEATING SYSTEM

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.4–9 P&ID TECHNICAL SUPPORT CENTER, HEATING, VENTILATION AND AIR CONDITIONING

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

9.5 OTHER AUXILIARY SYSTEMS

9.5.1 FIRE PROTECTION SYSTEM

The Fire Protection Program, has been developed to ensure that any single fire will not cause an unacceptable risk to public health and safety, will not prevent the performance of necessary safe shutdown functions, and will not significantly increase the risk of radioactive release to the environment. Compliance with fire protection technical requirements is shown in Table 9.5–1.

The Fire Protection Program establishes the fire protection policy for the protection of structures, systems, and components important to the safety of the plant and the procedures, equipment, and personnel required to implement the program.

The Fire Protection Program is under the direction of an individual who has been delegated authority commensurate with the responsibilities of the position.

To achieve and maintain a high level of confidence for the Fire Protection Program, it has been organized and is administered using the defense-in-depth concept. The defense-in-depth concept assures that if any level of fire protection fails, another level is available to provide the required defense. In fire protection terms, this defense-in-depth concept consists of the following levels:

a. Preventing fires from starting.

b. Early detection of fires that do start and controlling and/or extinguishing them quickly so as to limit their damage.

c. Designing the safety system so that if a fire should start in spite of the fire prevention program, and if it should burn for a considerable period of time in spite of fire suppression activities, it will not prevent the safe shutdown of the plant

None of these levels can be perfect or complete, but strengthening any one level can compensate in some measure for weaknesses, known or unknown, in the others.

The following source documents form the basis for the Millstone Unit 3 nuclear power plant’s fire protection program.

<u>Source Documents</u>

- 10 CFR 50, Appendix A, “General Design Criteria for Nuclear Power Plants.”
- 10 CFR 50, Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants.”
- NUREG-0800, Nuclear Regulatory Commission (NRC), Branch Technical Position, CMEB 9.5-1, Rev. 2.

- NRC Generic Letter 86-10, “Implementation of Fire Protection Requirements.”
- In terms of addressing and complying with the listed source documents, the following NU programs and procedures have been implemented:

Compliance Documents

- “Fire Protection / Appendix R (Fire Safe Shutdown Program Procedure”
- Millstone 3 Fire Protection Evaluation Report
- Millstone 3 Fire Fighting Strategies
- Millstone 3 BTP 9.5-1 Compliance Report

9.5.1.1 Design Bases

The Fire Protection Program involves several levels of fire protection features in support of its defense-in-depth concept. For a more detailed summary of the features/programs provided, refer to the appropriate section of the Millstone 3 Fire Protection Evaluation Report (FPER), as listed below:

9.5.1.2 System Description

Millstone 3 FPER, Section 4, Plant Design Features, contains an explanation of the various fire protection features, ventilation capabilities, access and egress routes, emergency lighting, and communication systems as well as active support systems that have been provided in order to safeguard plant systems/operations from a damaging fire affecting its safe shutdown capabilities. The individual fire protection system types and general schematic layout are shown in Figure 9.5–1.

9.5.1.3 Safety Evaluation

Millstone 3 FPER, Section 5, Fire Hazard Analysis (FHA), provides an area-by-area detailed fire analysis of the various areas/zones within Millstone 3. This section details the equipment within the various areas/zones of the plant defined by construction design features. The analysis includes a discussion of fire protection features that are installed and the postulated fire and its consequence on plant operation.

Millstone 3 FPER, Section 6, Safe Shutdown Evaluation, provides a brief summary of the safe shutdown systems available after a postulated fire in each area/zone of the plant. An in-depth, detailed review/analysis is provided in the Millstone 3 BTP 9.5-1 Compliance Report. Millstone 3 FPER, Section 7, Support Systems, provides a brief summary of the active support systems required for the functions shown on Section 6 Figures 6-1.1 through 6-10.

9.5.1.4 Inspection and Testing Requirement

Millstone Unit 3 Fire Protection Technical Requirements Manual, 3TRM-7.4, contains the fire protection operability requirements listing (formerly known as Technical Specifications Governed Systems). Administrative controls and testing/surveillance requirements to ensure that an adequate level of fire protection is maintained at all times, are provided. This listing also contains limiting conditions and action statements to govern off-normal status of installed systems.

9.5.1.5 Personnel Qualification and Training

Millstone 3 FPER, Section 3.2, Fire Protection Organization, contains the organizational structure for overall responsibility for the Fire Protection Program at Millstone 3.

Millstone 3 FPER, Section 3.3, Fire Brigade and Training – The Millstone Station Fire Fight Training Program establishes the requirements of, and responsibilities for, the training of fire brigade personnel. BTP 9.5-1, Appendix A, provides the guidelines for developing the program.

Millstone 3 FPER, Section 3.4, Quality Assurance – The Quality Assurance Program has been applied to the fire protection systems, components, and programs providing fire detection and suppression capabilities to those areas of the plant that are important to safety.

9.5.2 COMMUNICATION SYSTEMS

9.5.2.1 Design Bases

Reliable communication systems are provided for intra-plant, intra site, and plant-to-off site which meet the requirements of operation and maintenance of the unit. Multiple communication systems are provided to ensure the capability to notify the necessary personnel of the presence of an unsafe condition so that corrective measures can be taken. Physical and electrical independence is maintained between the systems.

These communication systems provide effective communications between plant personnel in key operating vital areas during the full spectrum of accident or incident conditions (including fire) under maximum equipment operating noise levels. The design is based on previously reviewed plants with satisfactory operating experience. The communications systems for fire fighting meet the requirements of Regulatory Guide 1.120.

9.5.2.2 System Design

9.5.2.2.1 Intraplant and Intrasite Communications

Intraplant and intrasite communications consist of the following systems:

- plant switching network (Private Branch Exchange (PBX) and connected telephones and data equipment)

- automatic ringdown telephones
- control room intercom system
- voice paging system
- evacuation alarm system
- maintenance jack system
- fuel handling carrier phone system
- sound-powered telephone system
- station trunked radio system
- Unit 3 Simulator
- multiple telemetering systems for station data

A description of these systems follows.

Plant Switching Network

The plant switching network or private branch exchange (PBX) is a telephone system consisting of standard telephones, multiline telephones, a digital PBX, cellular telephones, cellular base stations, and a radio exchange.

The PBX and its associated telephones allow communication throughout the plant by dialing the appropriate four-digit extension number. Communication off site, is accomplished by dialing the appropriate telephone number(s) or tie line code(s).

The plant switching network is operated at (-) 48V DC power, which is provided by rectifiers. The rectifiers also provide a charging and float current to maintenance free batteries, which are the emergency battery backup system.

The plant switching network is directly coupled to the Public Switched Network (refer to Section 9.5.2.2.2) and the voice paging system.

Automatic Ringdown Telephones

There are on site automatic ringdown telephones installed in the Unit 3 Control Room. These telephones are configured to ring at the terminating end when the handset is lifted from the phone. Automatic ringdown telephones ring from the Unit 3 Control Room to the following on site locations: Operational Support Center (OSC), Security, and the Technical Support Center (TSC). Typically, automatic ringdown telephones are independent of the Plant PBX systems. Refer to off site communications, multiple dedicated automatic ringdown telephones, Section 9.5.2.2.2, for additional information on this system.

Control Room Intercom System

The control room intercom system provides a communication link between the control rooms of Units 2 and 3. The intercom operates independently of the PBX and voice paging systems.

Voice Paging System

The intraplant/intrasite voice paging system provides communications from the control room to all buildings and control areas within the unit. In addition, through interconnections with the PBX, this system provides communication from one control area to any other. Isolation is provided between the two systems which have different operating voltages and impedances. The intraplant/intrasite voice paging system is an independent system using separate amplifiers and speakers at each paging station. Public address loudspeaker stations are provided in buildings which comprise the plant and in the outside areas surrounding the plant. Access to voice paging speakers is provided and initiated by dialing a code number from any designated plant dial telephone. The control room has priority access to the public address system. This access bypasses the plant switching network.

The voice paging system consists of loudspeaker stations, amplifiers, a telephone interface, two page override handsets, and a multitone generator. The power source for most of the system is a nonvital bus, powered by inverter INV-5 (Figure 8.3–2). The power source for parts of the system that serves some outlying buildings and some yard areas is the Technical Support Center electrical distribution system.

The loudspeaker stations are suitable for operation in conjunction with the loudspeaker amplifiers. Horn-type speakers have accessories suitable for mounting on horizontal or vertical structural surfaces. Mounting hardware permits orientation of horn-type speakers in both azimuth and elevation and locks them in the desired position. Voice coil terminals of all drivers are marked for polarity.

The amplifiers are suitable for operation on a 120 V (±10 percent), 60 Hz, single-phase supply. Level control is provided to regulate amplifier output and to prevent overdriving at any stage. Rated output of unit loudspeaker amplifiers is not less than 12 W. The output transformers for the loudspeaker amplifiers have taps for 8 and 16 ohms.

Each handset station includes a handset, a hookswitch, amplifier, terminal facilities, page/party spring-loaded selector switch, and 6 feet of self-coiling cord. The handsets include a magnetic receiver and a low impedance noise cancelling transmitter. These handsets are located in the control room and at the auxiliary shutdown panel, and include an override control for paging.

Evacuation Alarm System

The evacuation alarm system is comprised of a multitone generator, and it utilizes the amplifiers and speakers associated with the voice paging system. The integration of equipment from these two systems provides an effective warning system for site emergencies.

The multitone generator acts as the signal source for the alarm system. This generator is capable of producing five distinct tones: steady, pulse, siren, warble, and yelp. The generator consists of an oscillator/amplifier unit which is housed in a 16-gauge steel enclosure. All connections to the amplifier unit terminate in a plug on the amplifier chassis. A self-aligning receptacle in the enclosure accommodates the plug. A well-marked terminal strip mounted inside the enclosure provides for external wiring. All electrical components in the amplifier unit are premium-grade industrial type.

The various tones are produced individually by closing the contacts between the appropriate points on the terminal strip. The site evacuation “yelp” tone, a varying tone between 400 and 840 Hz, is activated remotely by a switch in the control room(s). The tone is transmitted by the generator over the voice paging system and is heard throughout the site. The emergency tone overrides any voice paging.

Maintenance Jack System

The maintenance jack system, which is utilized for calibration and maintenance, consists of amplifiers, headsets, handsets, and a network of plug-in jack stations with five-party selector switches located throughout the plant. Its power source is a nonvital bus powered by inverter INV-5 (Figure 8.3–2).

Jack stations are mounted on control panels or in separate enclosures. Each station contains a six-position selector switch (position for each of the five channels and an off position) and a receptacle to receive the plug unit of the headset or handset. Those jack stations that are mounted in separate enclosures have a provision to cover the receptacle when the station is not in use.

Headsets and handsets contain speaker(s), a microphone assembly, a cord, and a plug suitable to mate with the receptacle of the jack stations.

A system amplifier (located in Emergency Switchgear Room 2, control building, elevation 4 feet 6 inches) consists of five independent amplifiers each capable of driving a channel.

The maintenance jack system does not interface with any other communication system.

Fuel Handling Carrier Phone System

The fuel handling carrier phone system consists of an amplifier, jack plug stations, and handsets. Its power source is a nonvital bus powered by inverter INV-5 (Figure 8.3–2).

Jack stations are mounted in separate enclosures. Each station contains a receptacle to receive the plug unit of a handset, as well as provisions to cover the receptacle when the station is not in use. The jack stations are of single channel design.

Handsets include a speaker, a microphone assembly, a cord, and a plug suitable to mate with the receptacle of the jack stations.

The amplifier (located in the auxiliary building, elevation 43 feet 6 inches) is a single-party type component, capable of driving the single channel.

The jack stations are located on the spent fuel pool bridge, manipulator crane, five in the containment at various elevations, and four in the fuel building.

The fuel handling carrier phone system does not interface with any other communication system.

Sound-Powered Telephone System

The sound-powered telephone system consists of a master station, a switch box, and 16 substations with handsets. The system is self-powered.

Each substation includes a handheld telephone with a push-to-operate button located on the handset, a handset holder, and a wall-mounted cast aluminum case containing a manually operated magneto generator for call signaling and an audible call-signal device.

The master station, in addition to the equipment furnished with a substation, includes a selector switch (for calling substations individually) and a switch box containing sixteen 6-pole switches for disconnecting any faulted substation cable in the system.

The master station is located in the auxiliary shutdown panel area (control building, elevation 4 feet 6 inches). Substations are located in the emergency diesel generator enclosures, the emergency switchgear rooms, the main control room, and the Fire Transfer Panel Area in the Control Building, the Charging Pump Control Cubicle, the East MCC Rod Control Area, and the Pipe Penetration Area in the Auxiliary Building; the Motor Operator Vent Valve Area in the Main Steam Valve Building; the Train “A” Room and the Train “B” Room in the Circulating and Service Water Pump House; and the Auxiliary Feed Water pump 1A Cubicle, the orange/purple MCC area, the Manual Feed Isolation Valve area, and the Pipe Tunnel Area in the Engineered Safety Features Building.

The sound-powered telephone system does not interface with any other communication system.

Station Trunked Radio System

This is a digital Harris tri-band Trunked Radio System. The system is a redundant two site design with a Distributed Control Point (DCP) Simulcast, Multiband (800 MHz, UHF and VHF), VIDA Foundation Core, P25 multiband Radio Frequency (RF) communication system that does not require user intervention.

Each RF site consists of six (6) 800 MHz Repeaters, two (2) UHF (450 MHz) Repeaters and two (2) VHF (150 MHz) Repeaters. The Trunked Radio system broadcasts information simultaneously (i.e. the same information, at the same frequency at the same time) from redundant repeater locations to achieve high reliability and availability. Singe band radios will be used by non-security personnel on the 800 MHz channels only. If jamming the 800 MHz system were to occur, only multiband radios available to Security and Operations personnel will automatically move to another frequency (UHF or VHF).

Switching to the UHF or VHF channels is done seamlessly and the users are not aware that it is being done. Once the 800 MHz channels are available, the system automatically returns the standard 800 MHz channels.

The Trunked Radio system consists of two redundant equipment sites; The Primary Site is located in Building 405/1 and the Secondary Site is located in Building 475/1 (Main Communications Room). The Primary Site is powered from a non-essential power source through security distribution equipment and backed up by security emergency power supplies. The Secondary Site is powered from an independent source (i.e. Waterford/Flanders Line) and backed up by a dedicated Diesel Generator and Uninterruptible Power Supply (UPS) providing continuous power with enough run time for the generator to start. A Network Switching Center (NSC), referred to as the Voice Interoperability Data and access (VIDA) Foundation Core, is installed at the Secondary equipment site (475/1). The NSC provides the capability for users to configure system settings. The NSC is powered by the same source as the Secondary Site equipment (Flanders Line) and backed up by the same UPS and Diesel Generator.

Two (2) each Harris Symphony Dispatch Console are installed in CAS and SAS. The Dispatch Consoles allow Security personnel to access NSC configuration applications to modify talk groups, tracking modules to review calls received, and allows for the configuration of monitoring modules. The Dispatch Consoles receive backup power from a non-vital source with battery backup. If the NSC fails or looses power, the Dispatch Consoles will lose communication with the RF sites, however handheld radio communications will continue to operate and prove backup communications capabilities until the NSC is restored.

Two (2) 800 MHz (746 - 960 MHz) Panel antennas, a dual array VHF (138 - 174 MHz) and a dual port UHF (406 - 470 MHz) antenna are installed on the Millstone Stack at the 135’ Elevation to provide radio communications to the Secondary Radio Equipment Site, designed to withstand windspeeds up to and including 145 mph.

Five (5) GPS antennas are installed on the roof of Building 405(2) and the roof of Building 475 (3) to provide simulcast timing between the Primary and Secondary Site radio equipment.

Wideband Discone antennas (118 MHz - 3GHz) antennas are installed for the MP2 Control Room (Building 118) and MP3 Control Room (Building 317) to provide tri-band radio communications to Security and Operations. Designed to withstand windspeeds of up to and including 145 mph. See Section 9.5.2.2.2 for Control Room radio equipment details.

Two (2) additional wideband Discone antennas (118 MHz - 3 GHz) are installed on Building 201 (SAS) and building 405 (CAS), designed to withstand windspeeds up to an including 145 mph. A Radio control Station and Desktop Radio Remote Controller in each location will provide backup multi-band radio communications to CAS and SAS.

Station Operators and Security personnel communicate via the Trunked Radio system using hand-held portable radios. Each user group has radios and battery charging stations.

A one-channel, analog-based 900 MHz radio system is provided to the Site Security in the event of a failure of the primary 800 MHz radio system. The 900 MHz repeater is located in the CPF Building. This repeater is capable of 100 watts of RF power output with continuous duty operation. The primary power source is 120 VAC and the backup power source is battery. The individual portable radio is also equipped with a small antenna which provides a “portable-to-portable” feature between the radios. An omnidirectional antenna is mounted on the roof of the CPF Building and the installation design is such to withstand windspeeds up to and including 100 mph.

In addition to the 800 MHz and 900 MHz compatible antenna located on the roof of the Auxiliary Building, antennas are also located on Warehouse Number 5 (Building 435), the Technical Support Center (Building 315), and the Security Operations Center (Building 405). These antennas are connected to coaxial type antenna cables distributed throughout the interior of these buildings.

Telemetering Systems

Telemetering equipment to assist load dispatching is also provided in the control room.

Unit 3 Simulator

A new Harris Radio Control Station is installed just outside the MP3 Simulator Control Room with a Desktop radio Remote Controller inside for Security and Operations training purposes. An 800 MHz antenna is installed on the Simulator Building roof.

9.5.2.2.2 Off site Communications

The off site communication systems consist of the following:

- public switched network (off site dial telephone system)
- Emergency Telecommunication System (ETS)
- multiple dedicated automatic ringdown telephones
- multiple radio systems

A description of these systems follows:

Public Switched Network

The public switched network is operated by various telephone companies (i.e., SNET) and connects various outside agencies.

The public switched network is tied directly to the plant switching network with multiple central office trunk lines. The plant switch network is also tied remotely to the public switched network through dial repeating tie trunks.

Federal Telecommunications System (FTS 2000)

The NRC currently provides reliable long distance telephone service to nuclear power plant sites and remote Emergency Operations Facilities (EOFs) for the following six essential telecommunications functions:

Emergency Notification System (ENS) - Unit Control Room, Technical Support Center (TSC), and Emergency Operating Facility (EOF).

Reactor Safety Counterpart Link (RSCL) - EOF and TSC.

Management Counterpart Link (MCL) - EOF and TSC.

Local Area Network (LAN) - EOF and TSC.

Protective Measures Counterpart Link (PMCL) - EOF, and

Health Physics Network (HPN) - EOF.

Multiple Dedicated Automatic Ringdown Telephones

This system consists of auto-ringdown phones from the Millstone 3 control room to: the State Police Troop E, the Waterford Police, the site Emergency Operations Facility, Connecticut Valley Electric Exchange (CONVEX), and ISO New England (Independent System Operator). All off site auto-ringdown phones receive their power for signaling and ringing from SNET New London office via individual hard wire pairs. All circuits are independent of the station PBX. As part of the emergency communications system, the locations and connections of the automatic ringdown telephones are illustrated in the Millstone site Emergency Plan.

Multiple Radio Systems

The off site multiple radio systems include the following:

- CONVEX Command Control Network (CCN); (Tone Alert)
- Waterford Police System

- State Police system;
- VHF radio paging system

The radio console (400 panel) installed in the Millstone 3 control room consists of five individual bays secured together as a consolidated unit. The total length of the equipment is 92 inches with a height of 43.75 inches and an overall depth of 29.5 inches.

Three outbound bays contain telephone equipment, two on the left and one on the right. The radio consoles two inner panel sections have had their internal communication components removed and the front panels replaced with blank plates. In their place is installed a dedicated Radio Remote Control, powered from a local receptacle receiving power from 3IHC-PNL400 which is fed from 3VBA-PNL-5C.

A dedicated Radio Control Station installed just outside the Control Room in the Tagging office is powered from Panel 3C3 and a wideband discone (118 MHz to 3 GHz) antenna is installed on the Roof of Building 317. This radio configuration provides the Millstone 3 Control Room Operators tri-band (800 MHz, UHF and VHF) radio communications with associated onsite as well as offsite radio facilities (as outlined above). The identical dedicated standalone radio system is installed in the Millstone 2 Control Room.

The Radio Control Station is installed outside the required EMI boundary to endure that unintentional actuation of vital compounds or false indications are not caused by keying of the radio control stations in the Control Rooms.

A dedicated talk group established to provide direct communications between the Control Room Operators and Security is provided. The Desktop Radio Remote Controller will be turned to this talk group, at a desirable volume, but will be quiet in the Control Room environment a all times, until Security supervisors feel the need to page the Control Room Operators and vise versa for either emergency communication or procedural testing of the radio system. Following a page, Operators can tune the Desktop Radio Remote Controller to any available talk group for normal or emergency communications, then return to the dedicated quiet talk group afterwards.

Radio communications with the required outside agencies, Waterford and State Police as well as the Connecticut Valley Exchange (CONVEX) will be made available to operators through the Trunked Radio System via the Interoperability Gateway (IOG) installed in the Network Switching Cabinet (NSC), located at the Secondary Radio Site in Building 475 first floor. The IOG will provide the interface between the existing legacy Radio Control Stations, and associated antennas installed in the CPF Analog Microwave Room and the (Bldg. 212) rood and the Trunked Radio System, making radio communications with outside agencies available to any talk group that is programmed to have access to them.

Command Control Network (CCN)

The CONVEX CCN is a two-way radio system using tone alert signaling to provide communications among the control room, the CONVEX load dispatcher and other key operating facilities.

This system is controlled by the radio console in Units 2, and 3 via an Interoperability Gateway (IOG) through the Trunked Radio System. The transmitter/receiver base station is installed in the CPF Building 212 telecommunications room. It is installed in an impact-resistant, 41-inch cabinet bonded to electrical ground. AC voltage is the primary power source. The base station is fully solid-state incorporating integrated circuitry, located on plug-in modules or independent printed circuit boards. Highly reliable reed switches are used for antenna switching. The base station produces 13.8VDC to supply power, and draws little current. Unheated, temperature compensated plug-in oscillator modules are used for frequency control. The unit contains a continuous duty transmitter that can operate indefinitely on full power. There are five front-mounted metering receptacles for ease of maintenance troubleshooting. The station is remotely controlled by tone frequencies. The wire line controlling the station need not have DC continuity for operation.

The base station is connected to the antenna via a jacketed one-half inch diameter semirigid coaxial cable. The cable is installed in cable tray OTX 850N which is dedicated to communication cables only. The cable ultimately terminates at the antenna mount on the CPF Building penthouse. The coaxial cable has the outer copper jacket bonded to ground before entry into the building. The coaxial cable has an impedance of 50 ohms and offers a combination of remarkable flexibility, high strength, and superior electrical performance. It includes a copper clad aluminum center conductor, a protective black polyethylene foam dielectric, a corrugated copper outer conductor, and a protective black polyethylene jacket. The antenna is rigidly mounted to a permanent bracket secured to the parapet of the CPF Building. It is a highly directional r-f radiating device with a power gain of 5 dB. The antenna is designed to withstand severe environmental conditions. Radiating elements are made of three-quarter inch diameter tubing and reinforced with 7/8-inch diameter sockets at the mounting boom. It contains direct ground lightning protection and has a wind rating of 97 mph. The installed antenna weighs 37 pounds.

Waterford Police Radio

The Waterford Police Department two-way radio system provides communications between the Waterford Emergency Communications Dispatcher and the control room. The system is controlled by the radio console in Units 2 and 3 via an Interoperability Gateway (IOG) through the Trunked Radio System. The base station is located in the CPF Building telecommunication room.

The antenna is installed on the CPF Building penthouse. It is provided with lightning protection and has a wind rating of 150 mph.

State Police Radio System

The State Police two-way radio system provides two-way communication between Millstone, local and state police barracks located in Montville, CT.

The system is controlled from the consoles located in Units 2 and 3 via an Interoperability Gateway (IOG) through the Trunked Radio System. The base station is located in the CPF Building telecommunications room. The station fully utilizes the advantages of solid-state circuits, reliability, small size ruggedness, and low maintenance requirements. Efficient heat radiators ensure safe operating temperatures for the transmitter power amplifier stages, and the power supply regulator transistors. The stations' primary power source is 120 VAC, and it is protected from over current conditions.

The base station is connected to the antenna via a jacketed 0.5 inch diameter semirigid cable. The cable is installed in cable tray OTX850N which is dedicated to communication cables only. The cable ultimately terminates at the antenna mount on the CPF Building penthouse. The antenna is rigidly mounted to permanent bracket secured to the parapet of the CPF Building penthouse. The antenna is a unity power gain omnidirectional antenna, with a wind rating survival of 100 mph.

Dominion Energy Emergency Notification System (DEENS)

The Dominion Energy Emergency Notification System (DEENS) is web-based emergency notification and callback verification software. This software is designed to meet the needs of nuclear power facilities, including the requirements of notification in accordance with 10 CFR 50 Appendix E and NUREG-0654. The software utilizes multiple distributed data centers, with flexible capacity, and full stack redundancy with multiple SMS and voice providers vetted to ensure no downstream inter-dependencies. When activated, the system will contact the Millstone Emergency Response Organization and State and Local agencies via email, SMS text messaging, cell phone and LAN line. Emergency event information is included in the emailed Emergency Notification Form (ENF) sent to the State and local agencies.

9.5.2.3 Design Evaluation

Administrative procedures prevent handheld station trunked radios from affecting the solid-state reactor protection and/or ESF systems.

The cables in the communication systems are independent from those of other systems and are shielded or isolated from power cables and any other sources of line noise which could adversely affect the audibility of the systems. The communication systems use twisted, balanced audio pairs to further reduce the effects of longitudinally induced magnetic noise.

All communication systems are physically and electronically independent. The failure of any system does not cause the malfunction of the other systems. To ensure high power supply reliability, nonvital systems (requiring power) receive power from the 120/208 V nonvital bus (Section 8.3.1), the Technical Support Center electrical distribution system, or the normal DC power system (Section 8.3.2). The plant PBX is provided with a backup power system using a rectifier and backup battery. The normal and emergency power supply systems for the Public Switched Network are located at the telephone company operating facilities.

9.5.2.4 Testing and Inspection

The design of the communication systems permits routine testing and inspection without disrupting normal communication facilities. The evacuation alarm system will be tested periodically in accordance with normal station procedure.

9.5.3 LIGHTING SYSTEMS

9.5.3.1 Design Bases

Station lighting provides adequate lighting during all operating conditions, accident conditions, transients, fire, and during the loss of off-site power. The systems provide, as a minimum, lighting intensities at levels recommended by the Illuminating Engineering Society (IES) Lighting Handbook 1981 Application Volume, IES Transaction on Nuclear Power Plant Lighting and NUREG-0700. Emergency lighting for fire fighting meets the requirements of Regulatory Guide 1.120.

Fluorescent and light emitting diode (LED) lamps are used for general lighting of the station.

Incandescent lamps are the only type of lamp used within the containment and in certain areas of the fuel building. LED lamps can be used in all areas of Fuel Building provided the lamp is certified Mercury free and can be mounted to meet Seismic II/I criteria.

High intensity lamps are used for high-bay and medium-height lighting and for roadways.

Lighting in the area of the main control board is controlled by dimmers to give the best resolution possible.

Illumination is provided in accordance with current OSHA requirements for means of access/ egress for all facilities. Exit signs are illuminated by the essential AC system. Lighting is provided immediately outside exits.

The normal AC lighting system is both physically and electrically separated from the essential AC.

The station lighting design is based on previously approved plants with satisfactory operating experience.

9.5.3.2 System Design

Station lighting comprises three separate systems.

1. Normal AC lighting system is supplied from the normal (i.e., “black”) 480 VAC motor control centers (Section 8.3.1) through dry-type 480/208-120 VAC, three-phase lighting transformers. This system provides general plant area lighting. Illumination levels conform to IES standards for access/egress and task areas.

2. Essential AC lighting system is supplied from the emergency (i.e., “orange” or “purple”) 480 V AC motor control centers (Section 8.3.1) through 480/240-120 VAC, single phase, dry-type voltage regulating transformers which are qualified as isolation devices. The output of the isolation transformers, although “black,” is run exclusively in conduit and does not share raceways with normal “black” power, emergency power, or with “black” power that originates from an isolation transformer supplied from the opposite emergency bus. The output of the isolation transformer is protected by a molded case circuit breaker. This system provides lighting for the control room, the emergency switchgear rooms (including the auxiliary shutdown panel), and other safety related and vital areas required to bring the plant to safe shutdown. In addition, access and egress paths for personnel evacuation throughout the station are provided with lighting from this system. The essential AC lighting operates continuously, with the exception of the lighting in the containment. Upon loss of off site (normal) AC power, the essential AC lighting is automatically reenergized via the emergency diesel generators as discussed in Section 8.3.1.1.3. Illumination levels provided by the essential lighting system upon loss of normal lighting meet the requirements for safety lighting as defined by the IES Transaction on Nuclear Plant Lighting and the IES Handbook-1981 Application Volume.

3. The DC emergency lighting system consists of individual 8-hour, self-contained, battery packs supplying fluorescent, halogen, and incandescent fixtures. Most battery packs are supplied with a trickle charge via the essential ac lighting system (reference Section 8.3.1.1.2) which, in the event of a loss of off site power, is supplied automatically from the emergency generator (reference Section 8.3.1.1.3). In some areas of the plant, these battery packs are supplied with a trickle charge via the normal ac lighting system (reference Section 8.3.1.1.1). The DC lighting system operates upon the loss of essential or normal AC lighting power (reference Sections 9.5.3.2 (1) and 9.5.3.2 (2)). Upon energization of the essential or normal AC lighting system (reference Sections 9.5.3.2 (1) and 9.5.3.2 (2)), the DC emergency lighting fixtures turn off. The DC lighting system is sufficient to provide emergency lighting for 8 hours unless AC lighting is returned sooner. The DC lighting system provides lighting in the following areas as required by IES standards:

    - Areas where operators should have sufficient illumination while maintaining safe plant operations and where time loss of normal and essential lighting could hamper their ability to function quickly and safely.

- Areas where operators must have sufficient illumination while maintaining the plant in a safe hot shutdown condition following a control room evacuation.

- Normal routes of travel to accomplish the above functions.

The illumination levels for the emergency DC lighting system for Millstone Unit Number 3, as defined by IES standards, are:

- Manned work stations listed below are illuminated to 10 FC maintained average at the panel surface.

Main Control Board, CB-9

Auxiliary Shutdown Panel, CB-1

Transfer Switch Panel, CB-1 and CB-2

Fire Transfer Switch Panel, CB-2

Generator Circuit Breakers, CB-1 and CB-2

Emergency Generator Panels, EG-3 and EG-4

- Access/egress routes between manned work stations will be illuminated to 0.5 FC average maintained.

- Slight hazards are illuminated to 0.5 FC minimum at the center point of the hazard.

- High hazards are illuminated to 2 FC at the center point of the hazard.

Other access/egress pathways identified via the Fire Protection Evaluation are illuminated by DC emergency silhouette lighting. The adequacy of this lighting is verified by field walkdown to be sufficient to allow the operators to access the task areas and perform the intended tasks. This approach is consistent with NRC guidance contained in Generic Letter 85-01, Section 4.1. Portable battery-powered lanterns are available to supplement the fixed lighting when and where required either to perform specific event-related tasks or to perform maintenance on safety related equipment. In addition, this lighting is supplemented with the Millstone Station Security Lighting for outdoor access/egress routes, and access to the Appendix R equipment cage in Warehouse Building Number 435.

9.5.3.3 Design Evaluation

Station lighting is provided to operate the unit safely under normal and accident conditions, including a single failure and loss of off site power.

All fixtures within the control room are seismically supported. Clips are provided to prevent the fluorescent lamps from breaking electrical contact and/or dropping out of the electrical sockets during a seismic event. Also, high quality ballasts are used to minimize the interaction to the Class 1E system.

9.5.3.4 Inspection and Testing

Design of the station lighting systems permits routine surveillance and testing of all critical lighting systems without disrupting normal lighting service.

9.5.4 EMERGENCY GENERATOR FUEL OIL STORAGE AND TRANSFER SYSTEM

The emergency generator fuel oil storage and transfer system (EGF) is a safety related system designed to supply fuel oil to the emergency diesel generator engines.

9.5.4.1 Design Bases

The design bases for the EGF are as follows.

1. The outside air summer design dry bulb temperature for the Millstone Point site of 86°F and the outside air winter design dry bulb temperature of 0°F.

2. In accordance with the codes and classifications listed in Table 3.2–1.

3. In accordance with General Design Criterion 2 and Regulatory Guide 1.117, for the ability of structures housing the system and the system itself to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods, as established in Chapters 2 and 3.

4. In accordance with General Design Criterion 4, for structures housing the system and the system itself being capable of withstanding the effects of external missiles and internally generated missiles, pipe whip, and jet impingement forces associated with pipe breaks.

5. In accordance with General Design Criterion 5, for the capability of the system and its components to perform its required safety functions. A single active failure cannot result in loss of the system-functional performance capabilities.

6. In accordance with Regulatory Guide 1.26, for the quality group classification of system components.

7. In accordance with Regulatory Guide 1.29, for the seismic design classification of systems components.

8. In accordance with Regulatory Guide 1.102, for the protection of structures, systems, and components important to safety from the effects of flooding.

9. In accordance with Regulatory Guide 1.137, for fuel oil systems design, fuel oil quality, and tests. Exceptions for time required to complete fuel oil testing noted in Table 1.8-1.

10. In accordance with ANSI Standard N195, fuel oil systems for standby diesel generators, except as noted herein.

11. In accordance with Branch Technical Positions APCSB 3-1 and MEB 3-1, for breaks in high and moderate energy piping systems outside containment.

12. In accordance with Branch Technical Position ASB 9.5-1 Appendix A, guidelines for fire protection at nuclear power plants.

13. In accordance with General Design Criterion 17, for the capability of the fuel oil system to meet independence and redundancy criteria.

9.5.4.2 System Description

The EGF (Figure 9.5–2) is an ASME III, Class 3 system except for the fill line, its associated strainer, and the flame arresters which are ANSI B.31.1, Class 4 (NNS). It provides fuel oil to the emergency diesel generators for operation under all plant operating conditions and during all design basis events. There is a separate fuel oil storage and transfer flow path for each emergency generator.

Each flow path consists of a fuel oil storage tank, two 100 percent capacity fuel oil transfer pumps, a strainer, a day tank, and piping to each respective diesel engine. The fuel oil transfer pumps maintain the level in the day tanks automatically as discussed in Section 9.5.4.5. Each day tank has two supply and one return connections to the fuel oil injection system, mounted integrally, and provided with its respective diesel engine.

The emergency generator fuel oil system has the following features.

1. Two tanks installed in an underground concrete vault one for each diesel engine. Each emergency generator fuel oil storage tank is sized to store approximately 35,000 gallons of diesel fuel oil. All openings are located in the top of the tanks. Openings are provided for filling and draining, sampling and sounding, level instrument connections, determining fuel level with a stick gauge, pump piping connections, and a manway. Each tank is separately vented to the atmosphere through a vent line fitted with a flame arrester.

2. Four full-capacity, electric motor-driven, vertical, centrifugal, tank-mounted, emergency generator fuel oil transfer pumps (Table 9.5–9) are supplied; two pumps for each emergency generator fuel oil storage tank. Each pump is provided with an orificed recirculation line back to its associated emergency generator fuel oil storage tank to provide a minimum flow for pump protection. A DC motor-driven fuel pump powered from a Class 1E source is provided in addition to the gear-driven engine-mounted pump to ensure starting of the diesel generator.

   Each pump has sufficient capacity to fill both day tanks with both emergency generators running, since the fuel consumption at rated load and speed for one emergency generator is 6.16 gpm.

3. Two emergency generator fuel oil day tanks; one for each diesel engine. Each emergency generator fuel oil day tank is sized to store approximately 550 U.S. gallons of diesel fuel oil. Each day tank feeds its respective diesel fuel oil injection system through two supply lines. Each tank is located at an elevation to provide sufficient positive head for its respective diesel fuel oil injection system suction. Each tank is located at an elevation conforming to a tank bottom elevation of 13 feet above the diesel generator's "bottom of skid" elevation. This fulfills the diesel engine manufacturer's recommendation of a minimum elevation of 12 feet above the diesel generator's "bottom of skid" elevation. Two return lines from the diesel fuel oil injection pumps, one to the day tank and one to the storage tank, are provided for excess flow. Openings are provided in the day tanks for piping connections, level instrumentation, and a manway. Valved drain connections are provided in the bottom of the tanks for removing any accumulation of condensation. Each tank is separately vented to the atmosphere through a vent line fitted with a flame arrester.

4. Only one (primary) pump is required to transfer fuel oil from a storage tank to the day tank. If it should fail, a backup transfer pump is also available. Each primary pump is equipped with its own fuel oil strainer. The strainers are conventional simplex oil strainers with removable baskets for easy cleaning. Each strainer ensures that the fuel oil delivered to the day tank meets the diesel generator manufacturer's standards of purity. The backup pumps provide storage tank fuel oil samples for particulate analysis. Therefore, no strainers are provided for these pumps in order to assure particulates are not removed from the sample stream.

5. An interconnection with two normally locked-closed valves between the two emergency generator fuel oil supply headers is supplied to facilitate the use of either tank to supply either emergency generator. One pump on each tank is arranged to allow transfer from the A electrical bus to the B electrical bus, or vice versa, by means of a 480 V, seismically qualified Class 1E, manually operated transfer switch, under administrative control, thus ensuring approximately a 6-day supply of fuel for one diesel generator. (See Sections 8.3.1.1.2 and 9.5.4.5).

6. A duplex fuel oil strainer is provided for each diesel generator by the manufacturer.

7. All piping and fittings are ASME III, Class 3, except for the fill line, its associated strainer, and the flame arresters which are ANSI B.31.1, Class 4. All piping and fittings in the system are 150 pound rating.

The fuel oil storage tanks are located in an underground concrete vault adjacent to the emergency generator enclosure. The tanks are separated by a wall 18 inches thick to provide the minimum calculated fire boundary between tanks. The vault's two foot thick concrete outside walls and roof provide the required tornado protection per Regulatory Guide 1.117. Access openings and pipe penetrations have water tight seals to provide protection of the vaults against the effects of flooding. The fuel oil transfer pumps are mounted directly on top of a flanged connection to the storage tanks. Removable concrete covers are provided on the vaults to facilitate pump maintenance or removal. The concrete vault covers are designed to provide tornado and missile protection. The pump strainers and discharge valves also are located in the vault area. The storage tank vents are located outside the vaults and terminated at 6 feet above finished ground grade in tornado and missile proof 2-foot thick reinforced concrete labyrinth enclosures. The labyrinth enclosures preclude the entrance of water into the fuel oil tanks through the vents. The common discharge line from each storage tank's transfer pumps and the overflow line are routed underground to and from the respective fuel oil day tank, which is located in the emergency generator enclosure. These lines run under the concrete structure to provide the required tornado missile protection. The fuel oil transfer pumps may be started and stopped manually from the emergency diesel generator panel located in the emergency generator enclosure. The fuel oil storage tank fill lines are located outside the vaults, terminated at an elevation of 3 feet 9 inches above finished ground grade. The fill lines are capped and locked to preclude entrance of water into the tanks. Should the fill lines become damaged, the fuel oil storage tanks also can be filled from within their enclosure through a manhole on the top of the tanks. In the event the fuel oil storage tank enclosure area is flooded, the tanks may be filled through their vent lines which are located well above the site flood stage of 24 feet 6 inches (refer to Section 2.4.2.3).

The day tank vents are located and terminated 1 foot 6 inches above the roof (elevation 51 feet 0 inches) of the emergency diesel generator enclosure in their own tornado- and missile-proof enclosure.

Fuel oil degradation due to the turbulence of sediment in the bottom of the fuel oil storage tank during the addition of new fuel oil is minimized by the following.

1. Normal fill line strainer (0.10 inch perforation size).

2. Primary fuel oil transfer pump discharge strainer (0.062 inch perforation size). The strainer is provided with a pressure differential indicating switch and alarm which activates a high differential pressure alarm on a local panel, and a local panel trouble alarm on the main board. If a high pressure differential exists that prevents sufficient fuel oil flow to the day tanks, the redundant fuel oil transfer pump will be automatically started on low-low day tank level.

3. Engine-mounted duplex fuel oil filter (0.00012 to 0.00020 inch). The filter is provided with a local dual pressure indicator and a pressure switch downstream of the filter which annunciates low fuel oil pressure on a local panel and a trouble alarm on the main control board. These filters are frequently monitored, and filter cartridges replaced when necessary.

In addition, the fill line for each fuel oil storage tank is located a sufficient distance from the fuel oil transfer pump to enhance settling of sediment away from the pump suction.

To enable fuel oil pump testing, test piping is installed off the pump discharge downstream of the system flow elements. This piping allows fuel oil to be directed to the storage tank bypassing the diesel day tank. Normally closed valves located in the test lines prevent bypass during transfer of fuel oil to the day tanks.

The emergency generator fuel oil storage tanks and the emergency generator fuel oil day tanks are protected from corrosion by interior and exterior corrosion protective painted coatings applied in accordance with Steel Structures Painting Council Standards PA1, Paint Application Guide for Shop, Field, and Maintenance Painting, and Department of Defense Military Specification MIL-C-4556D, Coating Kit, Epoxy for Interior of Steel Fuel Tanks. The paint type used on the interior is Ameron 56C Primer and Ameron 56C Finish, and on the exterior, Keeler & Long, Inc., 7107 Epoxy White Primer. Interior paint repairs are made using Mobil/Valspar 78D-7 Primer and Mobil/Valspar 78W-3 White Finish Coat or engineering approved equal. To preclude the need for cathodic corrosion protection, underground fuel oil piping is encased in concrete, and the fuel oil storage tanks, and all other piping in the fuel oil transfer system are located in underground concrete vaults.

A number of design features are provided to prevent occurrence of a fire. Both the storage tank and the day tank vents are routed outside their respective areas and are equipped with flame arresters.

Temperature detectors in the storage tank, day tank, and emergency generator enclosures alarm in the control room to notify the operator of a potential fire. Operator action is required to interrupt the power supply to the transfer pumps.

Fire suppression for each of the fuel oil tank vaults is provided by a total flooding carbon dioxide system that is actuated by heat detectors. A discharge by either carbon dioxide system is annunciated in the main control room.

There is a complete and separate fuel oil storage and transfer flow path for each emergency generator, each of which is located in a separate fire area. A fire in either flow path does not affect the operability of the other system from performing its designed task.

9.5.4.3 Safety Evaluation

As a result of the redundancy incorporated in the system design, the EGF system provides its minimum required safety function under any one of the following conditions:

- loss of off-site power coincident with failure of one emergency generator;
- loss of off-site power coincident with maintenance outage or failure of one emergency generator fuel oil transfer pump associated with each emergency generator; and
- loss of off-site power coincident with maintenance outage or failure of either emergency generator fuel oil storage tank.

Each of the emergency generator fuel oil storage tanks is sized to store sufficient diesel fuel oil for approximately 3 days of continuous operation of an emergency generator loaded to the 2000 hr. rating of 5335 kW. An interconnection with two normally locked-closed valves is provided between the two emergency generator fuel oil transfer pump discharge headers to facilitate the use of either tank to supply either emergency generator. A single failure does not compromise the independence of the two systems. There are no direct connections between the two systems. One pump on each tank is arranged to allow transfer from the A electrical bus to the B electrical bus, or visa versa, by means of a 480 V, seismically qualified Class 1E transfer switch manually operated under administrative control. Diesel oil meeting ASTM D975 requirements is provided by regular and emergency fuel oil suppliers. Emergency fuel oil suppliers can deliver fuel to the site within 24 hours after being contacted. Plant procedures ensure that, within 4 hours after an LOP or postulated accident occurs, action is taken to notify suppliers of a need for fuel oil. Fuel suppliers, both regular and emergency, can provide fuel oil using 8000-gallon fuel trucks. Fuel oil can also be supplied by railway tank car, if necessary.

Rail routings exist which would not be subject to the detrimental effects of floods. The railroads also can clear snow from tracks as required. Land routes for trucks have proved dependable regarding the ability to keep them clean even after heavy snowstorms. Since fuel can be obtained overland through varied suppliers at different orientations (west, north, and east) from the site via Routes 1, 95, or 395, adequate fuel availability despite the potential of flooding is ensured. The site access road does not become unusable during floods, and is cleaned frequently during snowstorms. Consequently, adequate provisions exist to obtain fuel from off site sources even in unfavorable conditions, and to extend fuel supplies for an operating single diesel generator to 7 days and beyond, as conditions require.

Additionally, should an LOP event occur, it has been estimated (see EPRI Report NP-2301) that off site power can be restored to the site 95 percent of the time within a 24 hour period. This estimate is based on data reported for nuclear power plants within the region of the Northeast Power Coordinating Council. During the 14 years the switchyard has been in operation, prior to the time Millstone 3 received its full power license, the Millstone site has experienced only one LOP. This event occurred when salt spray contaminated insulators in the switchyard, causing them to flashover. These insulators have since been replaced with ones having a considerably greater creepage distance which reduces the likelihood of flashover. In addition, an automatic salt contamination monitoring system was installed at the Millstone site in 1982. This system alarms at approximately 50 percent of the contamination level from salt-induced flashovers, further reducing a repeat performance.

The transmission grid to which the Millstone switchyard is connected is a highly integrated and reliable network which has not suffered an outage since November 1965. The fact that power to the New York City and Long Island areas was lost in 1977 without affecting Connecticut further attests to the reliability of the grid.

Grid reliability combined with a high probability of restoring off site power within 24 hours ensures that the present fuel oil storage scheme for the emergency diesel generators is adequate.

In addition, the availability and reliability of off site fuel oil supplies to replenish fuel oil storage tanks has been demonstrated. Consequently, the Applicant believes that grid reliability and fuel availability justify the position that having a 7 day on site fuel oil storage capability per diesel generator is not necessary. The Applicant, therefore, takes exception to this requirement in Regulatory Guide 1.137 and ANSI N195.

Each of the emergency generator fuel oil day tanks is sized to store 550 U.S. gallons of diesel fuel oil, in accordance with National Fire Protection Association (NFPA) Standards (Section 3.1). The day tank storage capacity supports engine continuous operation for various time periods depending on fuel oil level in the tank at the beginning of engine operation. At the shutoff level for the two fuel oil transfer pumps there is approximately 493 gallons of fuel stored in the tank (413 gallons usable volume) which corresponds to approximately 60 minutes of engine operation at the 2,000 hr. rating of 5335 kW. At the first makeup pump set point there is 372 gallons of fuel stored in the tank (284 gallons usable volume) which is sufficient to support approximately 42 minutes of engine operation at the 2000 hour rating. At the second makeup pump setpoint, the lowest level with auto makeup capability, there is 278 gallons (189 gallons usable volume) of fuel which is sufficient for 27 minutes of engine operation at the 2,000 hr. rating. In the standby condition, a minimum of 493 gallons of fuel is maintained. When water is removed or when draining of a day tank becomes necessary, a 1 inch drain line with a normally locked closed valve located at the bottom of each tank is used. The oil is drained to a portable container and removed from the emergency diesel generator enclosure. The portable container is brought into the enclosure only when draining of the tank becomes necessary.

The fuel oil day tanks and connecting piping to the fuel oil day tanks are located a minimum distance of 28 inches from the insulated diesel exhaust piping to preclude contact with these hot surfaces. Fuel oil piping to the diesel generator fuel pumps is directed to the opposite end of the diesel, away from the insulated exhaust piping.

The fuel oil day tanks are located in an area monitored by a flame detection system and protected with a sprinkler fire suppression system to mitigate the consequences of an open flame in close proximity to the fuel oil day tanks.

The day tank is designed for gravity feed to the emergency generators. The supporting structure is equipped with a drip pan to contain leakage of oil from the day tank. Oil level in the drip pan is monitored by a level switch (normal power only) which provides a signal to a high level alarm, located in the diesel enclosure, and a common alarm in the control room, initiating operator action to drain the drip pan. Oil in the drip pan is addressed by system design; i.e., the oil flows by gravity from the drip pan through a 4 inch floor drain line piped to the oil separator. Backflow prevention devices preclude oil backing up out of the floor drains in the event of a day tank rupture. Further details on this drain path are provided in the Millstone 3 Fire Protection Evaluation Report, as referenced in Section 9.5.1.

Prior to adding new fuel oil to the storage tanks, the following properties are verified: specific or API gravity, water and sediment content and viscosity. Analysis of the other properties listed in the applicable specifications are completed within 30 days of addition. This is an exception to Regulatory Guide 1.137, which requires that the test are completed within 14 days, but in agreement with Technical Specifications Section 4.8.1.1.2 testing requirements.

Each fuel oil storage tank is provided with a sump for water collection and removal. The fuel oil storage tanks are periodically sampled for water contamination and accumulated water, if detected, is removed. Removal of water precludes the growth of algae which can exist at the water-oil interface.

The sulfur content of the diesel fuel oil is 0.5 percent maximum (by weight) to minimize corrosiveness of sulfur compounds in the diesel engine exhaust gas. Other more restrictive sulfur content requirements may apply. Number two fuel oil is supplied which is in accordance with ASTM D975 and the ambient conditions below grade in a storage vault. Fuel oil supplied to the site is first checked for water content and sediment upon its arrival. If acceptable, it is off loaded from its supply source to the fuel oil storage tanks. Fuel is sampled for quality requirements as called out in ANSI N195 and Regulatory Guide 1.137 in accordance with Technical Specifications.

Each emergency generator fuel oil transfer pump receives power from its associated emergency generator (Section 8.3).

9.5.4.4 Inspection and Testing Requirements

After the initial hydrostatic test on the emergency generator fuel oil supply piping at completion of construction, all active system components and controls are functionally tested periodically in the Technical Specification. The diesel fuel oil is sampled periodically to determine possible contamination or deterioration of the oil in storage.

Fuel oil is sampled monthly to determine water and particulate content. If a high level of particulate is detected, the reasons for increased levels of particulate will be determined and appropriate action taken. If algae is found to be the cause of the high level of tank particulate, an appropriate action will address its treatment. Any accumulated water detected during sampling is removed when found.

9.5.4.5 Instrument Requirements

The diesel generator fuel oil storage and transfer system operating parameters are monitored, indicated, and controlled, locally or remotely, as follows.

The following instruments and controls are located on the emergency generator panels.

- Control switches and indicator lights for the emergency generator fuel oil transfer pumps.
- Annunciators that alarm when the following conditions exist for the emergency generator fuel system:
  - storage tank fuel level low;
  - transfer pump discharge strainer differential pressure high;
  - day tank fuel level low;
  - day tank fuel level low-low;
  - day tank fuel level high; and
  - day tank drip pan fuel level high (connected to normal power system only).
- Indicators that monitor the following parameters:
  - emergency generator fuel oil storage tank fuel level, and
  - emergency generator fuel oil day tank level.

The following emergency generator fuel oil system parameters are monitored by the plant computer:

- fuel oil transfer pump running;
- fuel oil transfer pump stopped;
- fuel oil transfer pump discharge pressure;
- fuel oil transfer pump discharge flow;
- day tank fuel level; and
- storage tank fuel level.

An emergency generator panel trouble annunciator is provided for panels A and B in the control room. The annunciators are energized when an alarm condition exists on the respective panel. In addition, the fuel oil day tank level low-low alarm has its own annunciator window for each tank on the main control board.

Emergency generator fuel oil day tank level indicators are provided on the main control board.

There is pressure indication from the discharge of each transfer pump in the main control room. There is a level indication from the fuel oil storage tank at each Emergency Diesel Enclosure, as well as in the main control room.

The fuel oil transfer pump can be manually or automatically operated. Each of the two emergency generator fuel oil day tanks is provided with level switches to automatically start and stop the associated emergency generator fuel oil transfer pumps in a LEAD-FOLLOW arrangement. The LEAD-FOLLOW emergency generator fuel oil transfer pumps for each tank are powered from the associated emergency bus. The “lead” emergency generator fuel oil transfer pump is started when its associated level switch in the emergency fuel oil day tank reaches a predetermined level. If the “lead” emergency generator fuel oil transfer pump fails to start and the oil level continues to decrease, the “follow” emergency generator fuel oil transfer pump is started when the fuel oil level reaches the predetermined low level switch setting. At this level, the low level alarm is on at the emergency generator panel to inform the operator of a malfunction. The emergency generator fuel oil transfer pumps stop automatically at a predetermined day tank high level. Level switch set points are determined in accordance with the guidelines of ANSI N195.

A manually operated transfer switch is provided for one of the two transfer pumps on each storage tank. When electrical power is lost to one of the storage tank pump systems, the transfer switch disconnects that pump from its motor control center and reconnects it to the electrical supply of the other storage tank pump system. This pump is then controlled manually by a circuit breaker.

9.5.5 EMERGENCY DIESEL ENGINE COOLING WATER SYSTEM

Each of the two emergency diesel engines is cooled by the jacket water and the intercooler water systems (Figure 9.5–3).

9.5.5.1 Design Bases

The redundant engine jacket water and intercooler water subsystems are joined at the common expansion tank. The system as a whole is completely self-contained within a closed loop. These systems are cooled by the service water system (Section 9.2.1). Only the jacket and intercooler cooling water are used for cooling the various engine components. The service water supply does not interface with the cooling water systems, except at the cooling water heat exchangers.

The engine-driven water circulating pumps (3EGS*P3 and 3EGS*P1) are of adequate capacity to limit the temperature of the jacket cooling water leaving the engine to the engine manufacturer’s specified limit of 165°F, and to maintain the temperature of the inter-cooler water leaving the air cooler water heat exchanger to 95°F under all conditions based on the extremes of the service water temperature (Section 9.2.1).

The jacket and intercooler water are controlled by temperature-regulating valves that maintain the engine cooling water at a uniform temperature, are of adequate size and capacity to perform their intended function, and include a method of bypassing the heat exchangers for fast engine warm-up.

The 500 gallon expansion tank, common to the jacket and inter-cooler water systems, is normally filled with 275 gallons of water. Adequate capacity at the expansion tank low level is available to compensate for system leakage, without draining the tank, for 30 days without makeup to the system. Table 9.5–2 presents the leakage analysis. The Seismic Category I expansion tank is located approximately 20 feet above the jacket and inter-cooler water pumps. This ensures that manufacturer’s NPSH requirements for these pumps are met for the entire 30 days of diesel generator operation at full load without additional makeup. Although the tank is designed to not require make-up for 30 days, evaluation has shown that operator action can be credited to fill the tank after 24 hours of EDG operation. In the event of a leak greater than what was assumed in the Manufacturer’s 30 day analysis, several non-safety related sources of water are available; Service Water provides the safety related make up source if required.

The makeup source of water for the emergency diesel engine cooling water system is provided from the condensate makeup and draw off system (Section 9.2.6). The makeup line penetrates the top of the diesel engine fresh water expansion tanks and is not safety related.

Chemical cleaning is not used in the emergency diesel engine cooling water system. The corrosion inhibitor treatment used is recommended by a cooling water system chemical supplier, approved by both the diesel manufacturer and diesel sub-vendor.

Each engine jacket cooling water system has a thermostatically controlled electric immersion water heater and electric motor-driven circulating pump. These components maintain the jacket cooling water system warm during standby conditions, to assist in the fast start capability of the engine and to minimize long-term engine wear.

9.5.5.2 System Description

The cooling water systems of each emergency diesel consist of the jacket water system and the intercooler water system (Figure 9.5–3). The jacket water system, which dissipates heat rejected from the cylinder liner jackets, turbochargers, and lube oil coolers, consists of a direct engine-driven water circulating pump, water temperature regulating valve, electric immersion heater (Table 9.5–9), motor-driven water circulating pump (Table 9.5–9), and heat exchanger.

The intercooler water system, which dissipates heat rejected from the engine air coolers, and outside bearing at the alternator end consists of a direct engine-driven water circulating pump, water temperature regulating valve, and heat exchanger.

The jacket cooling water cooler and the air cooler water heat exchanger are shell and tube types, are in accordance with the mechanical standards for TEMA Class “R” heat exchangers, and conform to the applicable edition of ASME III, Class 3.

The engine cooling water flows through the shell side, and the service water through the tube side of the heat exchanger.

Table 9.5–10 lists the types of diesel jacket cooling water system leakages, means used to detect these leakages, and the corrective measures that will be taken.

The shell side design pressure is sufficiently high to eliminate the possibility of overpressurization as a result of any mode of operation of the equipment supplied. The tube side design pressure is 150 psig. Tube material is 18 BWG, 90-10 Cu-Ni, per SB-111, Alloy 706.

The diesel engine cooling water system is chemically treated to preclude long-term corrosion and organic fouling. Water purity and chemistry are maintained in accordance with engine manufacturer's and corrosion inhibitor manufacturer's recommendations.

Corrosion inhibiting chemicals are added to the diesel engine cooling water system and periodic analysis of the cooling water is performed to verify that it meets specifications.

Samples of makeup water supplied from the condensate makeup and draw off system are taken periodically to ensure makeup water chemistry is within specified limits (Reference Section 9.2.6.4).

Table 9.5–3 lists the design data for the major components in emergency generator cooling water systems.

9.5.5.3 Safety Evaluation

The diesel generator cooling water systems are housed in the Seismic Category I emergency diesel generator enclosure (Section 3.8.4).

The diesel engine cooling water system is an integral part of the diesel engine. Section 8.3.1.2.6 provides the electrical single-failure evaluation of the diesel engine.

The emergency diesel generator engines and associated subsystems are independent and redundant (reference Sections 8.3.1.1.3 and 9.5.5.1). There is no sharing of cooling water subsystems or components between the two diesel generators. Each diesel generator has its own cooling water subsystems which are cooled by redundant service water trains.

Section 9.2.1 and Figure 9.2–1 describe the interface to, and the analysis of, the service water system.

No single failure or piping interconnections between the engine water jacket, lube oil cooler, governor lube oil cooler, and the engine air intercooler can cause degradation of both emergency diesel generator engines.

Protection from floods, tornadoes, and missiles is discussed in Sections 3.4.1, 3.3, and 3.5, respectively. Protection from high and moderate energy pipe breaks is discussed in Section 3.6.1.

The emergency diesel cooling water systems are Seismic Category I, as defined in Regulatory Guide 1.29 (Section 3.2.1). They are Safety Class 3 (Section 3.2.2) and designed to ASME III, Code Class 3, to the extent possible (Section 3.2.2). Emergency generator protective trip circuit bypasses are discussed in Section 8.3.1.

Certain engine-mounted components, not covered by ASME III, are designed in accordance with the diesel manufacturer's latest standards for reliability. These components include:

- lower header and flexible hose supply cooling water to the cylinder jackets and turbocharger;
- upper header, including orifices, returning cooling water from the cylinder jackets and turbocharger;
- piping and orifice supplying water to and returning water from the governor lube oil cooler;
- piping, pump, and controls associated with the cooling water keep-warm system;
- engine-driven jacket water pumps;
- flexible hoses and couplings.

The emergency diesel generator cooling water system is vented back to the overhead expansion tank to assure that the entire system is filled with water.

Manual valves are provided for isolating portions of the system for maintenance. Refer to Section 8.3.1.1.3 for quality group clarification locations.

9.5.5.4 Inspection and Testing Requirements

Section 8.3.1 discusses emergency generator testing requirements. All active system controls are periodically tested (Chapter 16).

9.5.5.5 Instrument Requirements

The emergency diesel engine cooling water system is provided with low pressure, high temperature, and low temperature alarm switches to alert personnel when the manufacturer's recommended limits are exceeded. A low level alarm switch is provided on the overhead expansion tank to alert personnel of coolant loss from the system due to excessive leakage. Section 8.3.1 discusses alarms and trips for the emergency generators.

Annunciators located on the emergency generator panels alarm when the following conditions exist:

- emergency diesel generator jacket coolant pressure low;
- emergency diesel generator jacket coolant temperature high;
- emergency diesel generator jacket coolant temperature low; and

- emergency diesel generator fresh water expansion tank level low.

A trouble alarm for each emergency diesel generator panel is located on the main control board and is alarmed whenever the associated panel has a condition alarmed on it.

Temperature regulating valves maintain the engine cooling water at a preset temperature range when the engine is running.

An electric heater controlled by a temperature controller has a local AUTO/OFF control switch. The heater is energized when the standby jacket cooling pump is running, jacket coolant temperature is less than a preset temperature and the control switch is in AUTO. The heater is de-energized automatically when the standby jacket coolant pump is stopped or the jacket coolant temperature is greater than a preset temperature. The heater is de-energized manually by placing the control switch in the OFF position.

The standby jacket coolant pump has a local START/STOP/AUTO control switch. The pump is started automatically when engine speed is less than a preset speed and the control switch is in AUTO or stopped when engine speed is above a preset speed. The pump can be stopped or started manually with the control switch.

The operability of the standby jacket coolant pump is verified by normal operation when the emergency generator is not running.

9.5.6 EMERGENCY DIESEL GENERATOR STARTING AIR SYSTEM

The emergency generator starting air system is shown on Figure 9.5–3.

9.5.6.1 Design Bases

Each emergency diesel generator is provided with a dedicated air starting system consisting of two separate subsystems. Each subsystem includes a motor-driven air compressor, an air receiver tank, all necessary valves and fittings, and a complete instrumentation and control system to provide pressurized air to one bank of seven cylinders. A normally closed cross-connect valve is installed between the subsystems in the discharge line from the compressor. Opening this valve allows maintenance to be performed. All air start functional requirements are satisfied in this abnormal configuration. Each subsystem is capable of starting the engine five times from an initial receiver pressure of 425 psig without recharging the receiver. The air start system (both subsystems operating in parallel) is able to crank the diesel engine to the manufacturer’s recommended rpm and enables the generator to reach voltage and frequency and begin load sequencing within 11 seconds, from receiver pressure of 350 psig. The one 11 second start can be achieved, regardless of whether the cross-connect valve is open or closed, as long as both receiver pressures are at or above 350 psig.

Each motor-driven air compressor has sufficient capacity (26.5 cfm) to recharge its associated air receiver in 30 minutes from minimum starting air pressure to maximum starting air pressure.

9.5.6.2 System Description

There are two emergency diesel generators for Millstone 3. Each generator has an independent air-over-piston starting system consisting of two separate subsystems. The air starting system can start the engine without off site power. However, on site power in the form of Class 1E 125 VDC source (batteries) is required for the operation of the air start solenoid valves. Each emergency generator starting air system includes the following components.

AC Motor-Driven Air Compressors (3EGA-C1A, C2A, C1B, C2B)

Each system is supplied with two air compressors (Table 9.5–9) that are driven by electric motors. Each compressor and motor are mounted on a welded steel baseplate and anchored to the building foundation. A pressure switch is used to start a compressor motor when the pressure in the associated air start reservoirs decreases to no less than 375 psi, and stop the compressor motors when the pressure increases to 425 psi (high setpoint). Each compressor has a free air delivery rate of 26.5 cfm and is equipped with an automatic loadless starting device to allow the compressor to come up to rated speed before they start compressing air. A safety valve is installed in the discharge line of the air compressor and is set at 500 psig. A normally closed cross-connect valve is installed between the subsystems in the discharge line from the compressors allowing maintenance to be performed on the compressors. This provides the capability for one compressor to supply air to its own associated air receiver and/or the air receiver in the opposite subsystem. When crossed connected, the operable compressor will charge both air receivers automatically based on the pressure signal from its respective receiver. Automatic operation of the compressor via the pressure switch is not provided when feeding the opposite receiver only; however, hand switches are installed to allow manual operation.

Starting Air Dryers (3EGA-DRY 1A, 2A, 1B, 2B)

Each air compressor is provided with a seismically mounted drying skid. Compressed air that will be delivered to the starting air receiver tanks is first passed through the drying skid. The skid components consist of an aftercooler, pre-coalescing filter, coalescing filter, desiccant type air dryers and a particulate afterfilter. The function of this equipment is to ensure that a clean, dry source of air is available for recharging the receiver tanks. Dual desiccant towers are provided on each skid to allow for continuous drying. Air is passed through one tower for drying while the second tower is being regenerated. At the end of each absorption cycle, the flow is automatically reversed by means of a programmed timer which operates to place the saturated tower into a regenerative mode and the regenerated tower into drying service. A moisture analyzer is used to monitor the outlet dew point of the dry air and provides an alarm if the dew point rises above 10°F.

Each dryer skid is provided electrical power from the 120 VAC, Class 1E distribution system via two circuit breakers in series. The two circuit breakers in series provide isolation between the power supply and the dryer skid. An isolation device is required because the dryer skids are not safety-related equipment (refer to Table 8.3–3).

Starting Air Tanks (3EGA*TK1A, 2A, 1B, 2B)

Two 30 inch x 108 inch air reservoirs that are manufactured in conformance with ASME III are provided for each system. By design, each reservoir supplies enough air to effect five starts from an initial receiver pressure of 425 psig. Vendor tests proved that each reservoir has a capacity to supply enough air to effect five starts from an initial receiver pressure of 350 psig. Each of the air reservoirs is equipped with a safety valve that is set at 450 psi and a manually operated drain valve that is used periodically to blow down any moisture that may have accumulated in the reservoir. These starting air tanks are complete with all necessary pressure gages, pressure relief valves, and all other necessary fittings for connection into the starting systems of the engine.

Air Start Solenoid Valves (3EGA*SOV26A, *SOV27A, *SOV26B, *SOV27B)

Each system is equipped with two solenoid operated three-way, two-position, normally closed magnetic valves which pilot an air admission valve in each of the air inlet lines to the engine. These air admission valves allow the starting air to enter the engine under the control of the air start distributor.

Each bank of seven cylinders has a separate air supply subsystem consisting of all valves and fittings and a complete instrumentation and control system. Normally, both subsystems and both air start valves are used when starting the engine. The emergency generator starting air system, exclusive of the motor-driven air compressors, starting air dryers, starting air tanks, and interconnecting piping, is an integral part of the emergency generator diesel engine.

The diesel engine starting sequence is as follows.

A diesel start signal causes operation of starting control relays which energize the air start solenoid valves which pilot the main air start valves and admits starting air to each bank of seven cylinders of the engine.

During starting, air pressure is applied to the starting booster device causing the control linkage and fuel injection pump racks to move toward the “max fuel” position.

Starting air rotates the engine and causes the firing to commence. As the engine speed increases, the tachometer relay senses when the engine reaches 115 rpm and causes the start control relays to de-energize.

De-energizing the start control relays causes the air start solenoid valves to become de-energized and shuts off the starting air supply to the engine.

If the engine fails to start during the cranking period of 7 seconds, the normally open contacts of the cranking time limit relays close to energize the start failure relay.

When energized, the normally open contacts of the start failure relay close to lock in the relay coil and keep the relay energized. Energizing the start failure relay also causes the normally closed contacts to open to energize the annunciator and de-energize the start relays.

De-energization of the start relays causes the normally open contacts to reopen and de-energize the air start solenoid valves.

During any restart condition, the engine shutdown reset push-button on the control panel must be operated in order to start the diesel engine. This will de-energize the start failure relay and the shutdown relay if it were energized.

A 0.19 cubic foot capacity, 450 psig design pressure, ASME III, Class 3 air tank is provided in the air supply line to each servo fuel rack shutdown and starting booster solenoid valve (3EGA*SOV25A&B). A check valve isolates the tank from the main starting air system. The air tanks are provided to ensure a source of air for positive fuel shut off in the event of loss of all starting air pressure in the main starting air system.

9.5.6.3 Safety Evaluation

A starting air system is supplied for each emergency generator capable of cranking the diesel engine to the manufacturer's recommended rpm and enabling the generator to begin load sequencing within 11 seconds. By design each air system consists of two separate subsystems each capable of starting an engine 5 times from an initial receiver pressure of 425 psig without recharging. Vendor tests demonstrated that each reservoir is also capable of starting an engine 5 times from an initial receiver pressure of 350 psig without recharging. The starting air system is housed in the Seismic Category I emergency generator building (Section 3.8.4). There is no sharing of starting air system components between the two emergency generators. A complete failure in one emergency generator starting air system will not lead to a failure of the other emergency generator to start. In the normal system alignment, a single active failure in either of the emergency generator's starting air subsystems will not lead to the loss of the other starting air subsystem. This design feature improves EDG reliability/availability. During compressor maintenance, the cross-connect valve may be opened. However, overall EDG train single failure criteria is unaffected by the cross-connect valve being opened.

Protection from floods, tornadoes, and missiles is discussed in Sections 3.4.1, 3.3, and 3.5, respectively. Protection from high and moderate energy pipe breaks is discussed in Section 3.6.1.

The emergency generator starting air system is Seismic Category I, as defined in Regulatory Guide 1.29 (Section 3.2.1), Safety Class 3, and designed to Quality Group C Standards (Regulatory Guide 1.26, Section 3.2.2), to the extent possible. Engine mounted components and the starting air compressors which are not covered in the rules of ASME III, Code Class 3 are designed in accordance with the diesel manufacturer's latest standards for reliability. These components include the following:

- engine mounted air start distributors;
- engine mounted air start valves;

- engine mounted starting booster air valve;
- engine mounted fuel rack shutdown and starting booster servo; and

The Seismic Category I starting air receiver tanks are of sufficient capacity to start the emergency diesel generator and operate the engine controls for at least 7 days.

In addition, a 0.19 ft^3 capacity, 450 psig design pressure, ASME III, Class 3 air tank is provided in the air supply line to each servo fuel rack shutdown and starting booster solenoid valve (3EGA*SOV25A&B). A check valve isolates the tank from the main starting air system. The air tanks are provided to ensure a source of air for positive fuel shut off in the event of loss of all starting air pressure in the main starting air system. However, a loss of this air will not result in the failure or shutdown of the emergency diesel generator.

9.5.6.4 Inspection and Testing Requirements

Test connections have been provided on the interconnecting piping between the emergency generator and starting air tanks. This enables the operator to manually bleed the storage tanks, and periodically, to test and check startup of the starting air compressors.

Moisture and other contaminants which might affect the air starting system are removed by the skid-mounted drying systems and by periodic blowdown of the air storage tank. Other plant operating procedures consistent with the recommendations of the diesel manufacturer have been developed to ensure proper functioning of the air starting system.

Section 8.3.1 discusses the emergency generator functional testing requirements.

9.5.6.5 Instrumentation Requirements

There are two air compressors and separate air systems for each generator. Each air compressor is equipped with a manual control switch and indicator lights, located on the motor control center. A pressure switch on the air receiver tank automatically starts and stops its associated compressor. This switch is set to start the compressor when the associated tank pressure drops no less than 375 psig and to stop the compressor when the pressure reaches the high set point pressure of 425 psig. The relief valves on the air receiver tanks are set at 450 psig and at each air compressor discharge at 500 psig to protect the system from overpressurization. The compressor motor is also protected against thermal overload.

If the receiver tank pressure drops to the low alarm point pressure of 360 psig, the condition actuates an alarm on the respective emergency generator panel and the emergency generator trouble alarm on the main control board. Each receiver tank is also provided with a local pressure indicator. In the event receiver tank pressure drops to 350 psig and the compressor is not available to recharge the receivers, the receivers still are able to supply a sufficient quantity of air for a minimum of one start and begin load sequencing within 11 seconds based upon actual field test data.

The shutdown control is also governed by the control air and starting air systems.

The shutdown control consists of an air cylinder and an oil cylinder in a two-compartment body. The air cylinder (linkage end) has connection to the starting air control pressure. During starting, the starting air pressure expands the cylinder by moving the piston which moves the linkage to the injection pump to admit fuel to the engine.

Control air pressure is connected to the cylinder opposite to the rod end through a line containing a shutdown solenoid valve. The engine is stopped when the shutdown solenoid valve admits enough control air pressure against the piston to move the piston which will move the injection pump linkage to the "no fuel" position.

The operability of the air compressors are verified by normal operation when the emergency generator is not running.

9.5.7 EMERGENCY DIESEL ENGINE LUBRICATION SYSTEM

Each emergency diesel engine lubrication system (Figure 9.5–3) lubricates and cools various emergency diesel engine components.

9.5.7.1 Design Bases

The engine driven lubricating oil and rocker-arm lubricating oil pumps have sufficient capacity to ensure adequate lubrication of main bearings, crank pins, camshaft bearings, valve gear, rocker arms, and all other wearing parts. The oil also provides a cooling media for the pistons.

Each engine lubricating oil system has a thermostatically controlled electric immersion oil heater and electric motor-driven prelubricating pump. These components maintain the main lubricating oil system warm during standby conditions, to assist in the fast start capability of the engine and to minimize long term engine wear.

The Mobilguard 312 lubricating oil in the rocker arm lubrication system has a pour point of 0°F. The oil is heated by conduction from the standby jacket coolant heating system which has a minimum temperature of 95°F. This maintains the operability of the rocker arm lubrication system when room temperatures are within expected ranges. If a failure of either emergency generator enclosure heating system occurs, a low room temperature alarm actuates at 52°F on Ventilation Panel 1 in the control room. In response to this alarm, operator corrective action would be taken. Actions that may be taken include:

- bringing in portable space heaters;
- increasing room temperature by turning on lights or equipment; and
- starting the emergency diesel generator.

The rocker arm assembly is prelubricated once a week for 5 minutes to establish an oil film on the rocker arm assembly. The oil film remains on the wearing parts of the rocker arm assembly to ensure lubrication during any emergency start. Therefore, it is not necessary to operate the motor-driven rocker arm pump in parallel with the engine driven rocker arm pump. The electric motor driven rocker arm prelube oil pump is powered from an electrical Class 1E power source.

Portions of the emergency diesel engine lubrication system are also designed to the following criteria.

1. General Design Criterion 2 for structures housing the system and the system itself being capable of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods.

2. General Design Criterion 4 for structures housing the system and the system itself being capable of withstanding the effects of external missiles and internally generated missiles, pipe whip, and jet impingement forces associated with pipe breaks.

3. General Design Criterion 5 for the capability of shared systems and components important to the performance of required safety functions.

4. Regulatory Guide 1.26 for quality group classification of the system components.

5. Regulatory Guide 1.29 for the seismic design classification of system components.

6. Regulatory Guide 1.38 for quality assurance requirements for the packaging, shipping, receiving, storage, and handling of items for water-cooled nuclear power plants. The Quality Assurance Program Description Topical Report describes the current QA standards.

7. Regulatory Guide 1.68 for preoperational and startup testing of the diesel engine lubrication system.

8. Regulatory Guide 1.102 for the protection of structures, systems, and components important to safety from the effects of flooding.

9. Regulatory Guide 1.117 for the protection of structures, systems, and components important to safety from the effects of tornado missiles.

10. Specific design criteria as follows.

    a. The operating pressure, temperature differential, flow rate, and heat removal rate of the jacket water system which is external to the engine are in accordance with recommendations of the engine manufacturer and are listed in Table 9.5–3.

b. The system has been provided with sufficient protective measures to maintain the required quality of the oil during engine operation.

c. Protective measures (such as relief ports) have been taken to prevent unacceptable crankcase explosions and to mitigate the consequences of such an event.

Relief ports are spring loaded relief valves that “quick open” crankcase doors on increasing pressure. The doors will “quick close” upon pressure relief.

d. The temperature of the lubricating oil is automatically maintained above a minimum value by means of an independent recirculation loop, including its own pump and heater, to enhance “first try” starting reliability of the engine in the standby condition.

11. Branch Technical Position ASB 9.5-1 for lube oil system fire protection.

12. Branch Technical Position ICSB-17 (PSB) for diesel engine lubricating system protective interlocks during accident conditions.

9.5.7.2 System Design

There are two emergency diesel generators for Millstone 3, each with an independent lubrication system. Each engine lubrication system, as shown on Figure 9.5–3, is self-contained, integral to the emergency diesel engine, and consists of the following three subsystems.

1. The rocker arm lubrication subsystem ensures lubrication of the rocker arm assemblies and protects the crankcase oil from contamination by possible cooling water and fuel leaks at the cylinder head upper deck level.

Subsystem Components:

Engine Driven Rocker Arm Lubricating Oil Pump (3EGO*P2A/B)

This pump takes suction from the engine mounted oil reservoir and discharges through the duplex filter to the upper cylinder header and lubricates the rocker arms during engine operation.

Electric Motor Driven Rocker Arm Prelubrication Oil Pump (3EGO*P1A/B)

This pump is operated 2 minutes prior to any manual engine start in order to prelubricate the rocker arm assemblies. Refer to Table 9.5–9.

Duplex Rocker Arm Lubricating Oil Filter (3EGO-FLT2A/B)

This duplex filter is provided to remove foreign particles, which may have entered the system, before they reach the engine.

Rocker Arm Lubricating Oil Reservoir

This reservoir provides the rocker arm lubricating oil subsystem with an adequate supply of lube oil. It is connected to the diesel engine lubricating system (lube oil header) by a float valve that controls the admission of lube oil to the reservoir. The reservoir is also equipped with a sight glass, a vent, supply and return line connections, and a drain connection.

Rocker Arm Oil Pressure Regulating Valve (3EGO*PCV22A/B)

This valve opens when the pressure becomes too great at the discharge of the duplex filter to allow some of the oil to be returned to the suction of the rocker arm engine driven pump.

2. The lubricating oil keep warm subsystem maintains the temperature of the engine lubricating oil between 115-135°F, enhancing the capability of the engine to come up to rated speed within the required 11 second time limit, without delay for engine warm up.

System Components:

Electric Motor Driven Prelubrication and Filter Pump

This pump is provided to prelubricate the engine prior to startup and to circulate oil through the keep warm heating system and lube oil filter. The pump takes suction from the engine sump (crankcase) via a strainer and discharges through a 15-kW electric heater to the lubricating oil header and engine. Refer to Table 9.5–9.

15-kW Electric Prelubricating Oil Heater

This heater is thermostatically controlled to maintain the lubricating oil temperature in the crankcase greater than the low temperature alarm setpoint of no less than 110°F. This maintains the oil system in a state of readiness for automatic startup from the standby condition, within the required 11 second time limit.

Lubricating Oil Filter

This filter is capable of retaining 98 percent of particles 5 microns and larger. The lube oil filter elements require replacement when the differential pressure exceeds 20 psi at the normal operating temperature.

Prelubrication and Filter Pump Suction Strainer

The strainer prevents foreign particles leaving the engine sump from entering the prelubrication and filter pump. The strainer is cleaned weekly initially, then at an interval determined by operating experience.

3. The diesel engine lubricating oil subsystem lubricates the main bearings, crank pins, camshaft bearings, and other wearing parts.

System Components:

Direct Engine Driven Lubricating Oil Pump (3EGO*P3A/B)

This pump is mounted below the governor drive and is gear-driven from the engine drive gear. It takes suction from the engine oil sump (crankcase) and discharges into the engine lube oil header.

Thermostatic Three-Way Temperature Control Valve (3EGO*TCV20A/B)

This valve controls the flow of lube oil to the lube oil heat exchanger during engine operation and maintains the temperature of the lubricating oil to the lube oil header between 125°F and 140°F under all conditions of load and ambient temperature. It also bypasses the flow of lubricating oil around the lube oil heat exchanger on startup of the engine.

Lubricating Oil Cooler (3EGS*E3A/B)

This shell and tube heat exchanger is used to transfer the heat picked up by the lubricating oil to the jacket coolant system and is suitable for the temperatures and pressures encountered in this service. This oil cooler is capable of controlling the lube oil (flowing through the shell) temperature between 125°F and 140°F by using the engine jacket cooling water (flowing through the tubes). The heat exchanger is designed in accordance with mechanical standards for TEMA Class "R" heat exchangers and conforms to the applicable edition of ASME III, Safety Class 3.

Lubricating Oil Strainer (3EGO*STR1A, 5A/1B, 5B)

This full flow strainer removes foreign particles from the lubricating oil before they reach the engine lube oil header. The lube oil strainer elements should be removed and cleaned when the differential pressure exceeds 10 psi at the normal operating temperature.

The protective measures for the lubricating oil system consist of oil filters and strainers that do not require power sources or alarms and are of the multiple element, continuous full flow type.

The crankcase vacuum system (Figure 9.5–3) includes a crankcase vacuum pump, oil separator, piping, and fittings. The crankcase vacuum system removes oil vapors from the diesel crankcase preventing the leakage of oil vapors through crankcase seals. The crankcase vacuum system can be started, if an accident signal is not present, either manually if the vacuum pump control switch is in the start position, or automatically if the control switch is in the auto position and the emergency diesel generator is running at greater than 360 rpm. Both operating modes are possible provided there is no vacuum pump motor thermal overload. The vacuum pump is powered from a safety-related motor control center as described in Table 9.5–9. The diesel crankcase is equipped with relief ports to mitigate the consequences of a crankcase explosion.

A 1,200 gallon capacity lubricating oil sump is provided to supply the engine with an adequate amount of lubricating oil during engine operation. The minimum recommended sump level of approximately 1,000 gallons would be reached after 5 days of operation at full rated load with a normal oil usage rate of 40 gallons per day. The lubricating oil sump low level is alarmed at the local control panel and a common trouble alarm is actuated in the main control room and at the plant computer. Upon reaching this minimum level, oil is added to the system without an engine shutdown. Adequate lubricating oil is stored on site to ensure 7 days of operation at rated load. An oil usage rate of 65 to 70 gallons per day is considered excessive and is one indication that an engine overhaul is needed.

Table 9.5–4 provides the design data for the major components in the emergency diesel lubricating oil system.

9.5.7.3 Safety Evaluation

The lubrication system is housed in the Seismic Category I emergency generator enclosure (Section 3.8.4). There is no sharing of lubricating system components between the two emergency generators. A single failure in the diesel engine lubrication system would not lead to the loss of more than one emergency diesel engine.

Protection from tornadoes, floods, and missiles is discussed in Sections 3.3, 3.4.1, and 3.5, respectively. Protection from high and moderate energy pipe breaks is discussed in Section 3.6.1. The emergency diesel lubrication system is Seismic Category I, as defined in Regulatory Guide 1.29 (Section 3.2.1).

The emergency diesel lubrication system is classified as Safety Class 3 and is designed to Quality Group C, as defined in Regulatory Guide 1.26 (Section 3.2.2) Standards and ASME III, Code Class 3, to the extent possible.

Certain engine mounted components as well as components either not covered by the rules of ASME III, Code Class 3 or not related to the safety function of the diesel engine are designed in accordance with the manufacturer’s latest standards for reliability. The components include the following:

- prelube and filter pump strainer;
- prelube and filter pump;

- three-way, three-position, three-port valve;
- 15 kW lube oil heater;
- three-way valve, plus piping, around the 5 micron oil filter;
- 1.5 inch check valve and a length of 1.5 inch piping; on outlet of 5 micron oil filter;
- three-way valve, plus piping, around the lube oil strainer;
- engine driven lube oil pump and suction strainer;
- rocker arm lube system; and
- crankcase vacuum pump and crankcase vacuum oil separator.

The condition of the lubricating oil in both the Rocker Arm and Engine Reservoirs is checked on a periodic basis, consistent with good maintenance practice and industry experience. The oil is analyzed for numerous parameters, including viscosity, percent water, oxidation, soot, fuel dilution, total base number, as well as the presence of various metals that are indicative of bearing wear. The results of the analyses are reviewed by maintenance and engineering personnel.

A vacuum pump, an additional protective measure available when an accident signal is not present, maintains a vacuum on the engine crankcase preventing the accumulation of oil mist which reduces oil leakage and minimizes the possibility of crankcase explosion.

Addition of lubricating oil is done by trained maintenance personnel using procedures developed and proven satisfactory during the preoperational and startup test program to prevent entry of deleterious materials into the engine lubrication oil system.

The diesel engine prelubrication system is self-contained and integral to the diesel engine. Continuous operation is permitted in accordance with the manufacturer’s recommendations. The “V” design of the diesel engine allows for lubricating oil to continuously drain down to the engine sump. This prevents the buildup of lubricating oil in the cylinders which could be blown into the exhaust system on engine start. The turbocharger lubricating system is self-contained and does not get its supply from the engine oil header thus preventing buildup of oil in the turbocharger housing during prelubrication of the engine.

Each diesel engine prelubrication system is periodically inspected during plant operation for possible leakage. This ensures against any dangerous accumulations of lubricating oil that could ignite during continuous prelubrication.

The prelubrication period for the rocker arm lubricating system is 2 minutes prior to any manual start which is in accordance with the recommendations of the diesel engine manufacturer.

9.5.7.4 Inspection and Testing Requirements

Section 8.3 discusses emergency generator inspection and testing requirements.

9.5.7.5 Instrumentation Requirements

Section 8.3 discusses emergency generator protective trips and trip circuit bypasses. Refer to Chapter 16, Technical Specifications, for periodic tests of active components.

A low lubricating oil level alarm is provided to alert personnel when the lubricating oil level in the sump falls below the manufacturer's recommended minimum level.

A high pressure alarm is provided to alert personnel when the pressure in the crankcase exceeds the manufacturer's recommended high pressure limit.

A high level alarm switch is provided to alert personnel when the oil level in the separate rocker arm lubricating, oil tank exceeds the manufacturer's recommended maximum.

A float valve connected to the main lube oil header provides makeup oil to the rocker arm lube oil reservoir and maintains the level above the manufacturer's recommended minimum. A low pressure alarm on the local panel and a local panel trouble alarm on the main control board are provided to alert personnel when the rocker arm lubricating oil pressure falls below the manufacturer's recommended minimum. Upon actuation of this alarm, the rocker arm lube oil reservoir level and the rocker arm lube oil duplex filter pressure differential is checked and corrective action taken to maintain operability of the rocker arm lube oil system. The diesel engine manufacturer has indicated that the low pressure switch in the rocker arm lube oil system provides an indication of low level in the oil reservoir. This low pressure indication is sufficient to warn the operators of low lube oil level. In addition, the rocker arm lube oil reservoir level is checked, in accordance with the manufacturer's recommendations, prior to any manual start, biweekly on engines on standby and daily an operating engines.

When the engine is running, actuation of any one of the low lube oil pressure switches will energize a main board annunciator and give a local alarm that the lubricating oil pressure has reached a dangerously low level. Actuation of any two of these low lube oil pressure switches will shutdown the engine.

High and low temperature alarms are provided to alert personnel when the oil temperature rises above, or falls below, the operating range recommended by the manufacturer.

The following annunciators are on each emergency generator local panel:

- rocker arm lube oil pressure low;
- crank case pressure high;
- lube oil sump temperature low;

- lube oil sump level low;
- lube oil temperature high;
- rocker arm reservoir level high; and
- lube oil pressure low.

An emergency generator local panel trouble annunciator for each panel is located on the main control board and is alarmed whenever a respective local panel annunciator is alarmed.

The prelube oil filter pump has a local STOP/START control switch and the motor has thermal overload protection. The rocker arm prelube oil pump has a local STOP/START control switch and a remote STOP/START control switch on the main control board. The motor has thermal overload protection.

The emergency generator prelube oil heater has a local OFF/AUTO control switch. When in AUTO, the heater is automatically energized when the following conditions exist:

- Emergency generator speed below a preset setpoint.
- Lube oil temperature below a preset temperature.
- Prelube oil filter pump running.

The emergency prelube oil heater is de-energized when any of the above conditions is not met or when the control switch is in OFF.

The operability of the prelube oil filter pump and rocker arm prelube oil pumps are verified by normal operation when the emergency generator is not running.

9.5.8 EMERGENCY GENERATOR COMBUSTION AIR INTAKE AND EXHAUST SYSTEM

The emergency generator combustion air intake and exhaust system supplies filtered air to the emergency diesel engine for combustion and releases exhaust gases to atmosphere (Figure 9.5–3).

Air is supplied from outside through filter and silencer to the diesel engine and is exhausted through a muffler to atmosphere. The system is QA Category I, nuclear safety-related except for the pipe from the muffler to the atmosphere which is QA Category II.

9.5.8.1 Design Bases

The safety-related portion of the emergency diesel combustion air intake and exhaust system is designed in accordance with the following.

1. General Design Criterion 2 for structures housing the system and the system itself being capable of withstanding the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, and floods.

2. General Design Criterion 4 for structures housing the systems and the system components being capable of withstanding the effects of external missiles and internally generated missiles, pipe whip, and jet impingement forces associated with pipe breaks.

3. General Design Criterion 5 for shared systems and components important to safety being capable of performing safety functions.

4. Regulatory Guide 1.26 for quality group classification of the system components.

5. Regulatory Guide 1.29 for the seismic classification of system components.

6. Regulatory Guide 1.68 for preoperational and startup testing of the combustion air and exhaust system.

7. Regulatory Guide 1.102 for the protection of structures, systems, and components important to safety from the effects of flooding.

8. Regulatory Guide 1.117 for the protection of structures, systems, and components important to safety from the effects of tornadoes.

9. Each emergency diesel engine is provided with an independent and reliable combustion air intake and exhaust system. The system is sized and physically arranged such that no degradation of engine function will be experienced when the emergency generator set is required to operate continuously at the maximum rated power output.

10. The combustion air intake system is provided with a means of reducing airborne particulate material over the entire time period that emergency power is required, assuming the maximum airborne particulate concentration at the combustion air intake.

11. Suitable design precautions have been taken to preclude degradation of the diesel engine power output due to exhaust gases and other dilutants that could reduce the oxygen content below acceptable levels.

12. Branch Technical Position ASB 3-1 and MEB 3-1 for breaks in high and moderate energy piping outside containment.

13. Branch Technical Position I CSB 17 (PSB) for diesel engine air intake and exhaust system protective interlocks during accident conditions.

9.5.8.2 System Description

The emergency generator combustion air intake and exhaust system (Figure 9.5–3) consists of ductwork filters, silencers, manometers, recorders, pressure indicators, mufflers, temperature monitors, exhaust pipe, and stack.

Each emergency diesel combustion air intake and exhaust system is capable of supplying 19,250 cfm of filtered outside air to the diesel engine for combustion, and exhaust 48,306 cfm of combustion gases to the outside atmosphere.

Outside air is drawn in through a sound attenuated, screened, missile protected wall opening and then through a filter of dry media and a silencer for each combustion air intake system.

On the outlet of the silencer, a manometer indicates the pressure in the duct at that point.

A pressure differential switch is installed across the air filter to measure the differential across the filter and alarm in the control room if the maximum allowable pressure drop of 3.0 inches water gage has been exceeded. Another pressure indicator is located at the inlet to the diesel engine for local indication.

Each emergency diesel exhaust system directs the diesel engine exhaust to the exhaust muffler through two Safety Class 3 pipes connected to expansion joints at the diesel engine outlet. A temperature element is located in each of the two outlet connections to monitor the exhaust gas temperature. The muffler is located in the ventilation exhaust plenum of each enclosure such that the emergency generator enclosure ventilation exhaust carries away the heat released by the muffler.

The exhaust stack is connected to the muffler outlet expansion joint. The stack goes straight up after the ventilation exhaust plenum and releases the exhaust gas at an elevation of 71 feet to avoid any combustion gases from being drawn into the intake (Figure 9.5–4). The maximum pressure drop allowed and designed for across the emergency diesel exhaust system is 10 inches water gage. The entire combustion air intake and exhaust system is seismically designed.

9.5.8.3 Safety Evaluation

There are no moving parts where failure could jeopardize system function in the emergency diesel combustion air intake and exhaust system.

The emergency generator combustion air intake and exhaust system is located within a Seismic Category I structure which is designed for missile, earthquake, and flood protection.

The combustion air intake is provided with a downward oriented low velocity air inlet plenum equipped with a screened opening. This precludes direct entrainment of precipitation into the emergency generator combustion air intake during either standby or operating conditions. Dust is prevented from accumulating within the diesel combustion air intake during standby conditions by the same oriented intake plenum. During diesel operation under conditions of high atmospheric dust concentrations, the dry extended media intake filter intercepts particulate matter before it reaches the diesel combustion chambers. Filter differential pressure is sensed by a differential pressure switch which actuates a high differential pressure alarm locally and a common trouble alarm in the control room. Surveillance is performed during diesel monthly availability testing (Section 8.3) to ensure diesel generator availability on demand.

There are no gas storage tanks in the vicinity of the emergency diesel generator enclosure which eliminates the possibility of any accidental gas release at the combustion air intake.

Gases stored on site, in containers having greater than 100 pound quantities, include nitrogen, carbon dioxide and hydrogen, as discussed in Sections 9.5.9.2, 9.5.1, and 9.5.9.1, respectively.

Degradation of the emergency diesel generators will not occur due to the release, intentional accidental, of any of these gases since the distance and intervening structures (service, control, and turbine buildings) between the gas storage area and the diesel combustion air intakes precludes significant concentrations from reaching the combustion air intakes. The location of the gas storage area is south of the containment structure as shown on Figure 1.2–2.

An analysis has been performed to determine whether the diesel generator operation could be affected due to CO_2 entrainment in the diesel combustion air intake. CO_2 at a maximum concentration of 50 percent issues from an opening at 20 feet above ground elevation in the 55-line wall of the control building as a result of suppressing a fire. The opening is a missile-protected structure which directs the emerging jet downward into the passageway between the control building and the emergency generator enclosure. Air is entrained prior to jet impact with the ground. The flow in this region is analyzed by a momentum jet model with an equivalent circular cross section. (Albertson, et al., 1950). At the point of impact the concentration is approximately 37 percent CO_2.

It is assumed that wind effects are limited to preventing a portion of the air-CO_2 mixture from escaping by flowing down the passageway away from the yard (emergency generator fuel oil storage area). This assumption produces the worst case condition of directing all the air-CO_2 mixture into the yard. A stabilized pool of the mixture eventually occupy the semi enclosed yard. A density-induced flow allows the air-CO_2 mixture to escape from the yard to an open area.

The propensity to locally entrain the air-CO_2 mixture into the superposed (upper) air layer and then into the diesel generator air intake is analyzed by a selective withdrawal model. (Harleman 1969).

The results of the analysis show that the limiting withdrawal rate is larger than the maximum air inflow rate of the diesel engine air intake. Consequently, the air-CO mixture in the yard is not drawn into the air intake and does not affect the performance of the diesel generator.

The emergency generator diesel engines and all auxiliary systems are designed to start and operate at rated load during a tornado which results in a decrease in atmospheric pressure of 3 psi in 3 seconds. The probability of damage to the diesel exhaust pipe by a postulated tornado missile has been evaluated using TORMIS methodology and found to meet the requirements of SRP Section 3.5.2 and Section 2.2.3.

There are no limiting assumptions used or exceptions taken when applying the NRC approved TORMIS Methodology to evaluate the acceptability of safety related components that are unprotected from tornado missile damage to meet the acceptance criteria of 10 CFR Part 100 per the NRC guidance found in SRP Section 2.2.3 (NUREG-800, Rev. 2).

The *normalized annual arithmetic mean tornado missile impact probability* “factor” has been credited in the evaluation to meet the acceptance criteria for unprotected safety-related SSCs not evaluated in the original Millstone 3 TOMRIS analysis for being exposed to tornado missiles which could negatively affect safe shutdown. This *normalized annual arithmetic mean tornado missile impact probability* is directly derived using the values obtained from the original Millstone TORMIS analysis. The TORMIS methodology remains intact with no exceptions when using this “factor”, but extends the TORMIS methodology to other unprotected components not directly assessed with the TORMIS software.

Because the original Millstone TORMIS results were extremely conservative, and was based on construction materials which are no longer being stored in areas that were taken into account, utilization of this “factor” is acceptable since the potential missle population is substantially reduced since Millstone 3 has been operational, thus the use of the normalized annual arithmetic mean tornado missile impact probability is conservatively bounded by the TORMIS analysis originally completed.

The point of exhaust of combustion gases to the atmosphere is approximately 28.5 feet above the combustion air intake; therefore, oxygen content requirements for combustion are not restricted.

Each emergency diesel generator exhaust pipe is a 40 inch diameter pipe which protrudes about 36 inches over the top of the diesel generator enclosure. The pipe is located toward the edge of the building. Typical snowfall depths would not exceed 36 inches in a 24 hour period. In addition, the Millstone 3 Environmental Report, Section 2.3.1.9, indicates a maximum snowfall depth of 48 inches in 2 days. Based on past experience with the Millstone Units 1 and 2 diesel generators (whose stacks are significantly smaller in diameter), snow accumulation in exhaust pipes has not been a problem. Since the exhaust pipes are located close to the edge of the building, drifting of snow into the pipes is not likely.

The emergency diesel generator exhaust is also equipped with a normally open low point drain. Any frozen precipitation would be melted during the monthly diesel generator availability tests and drained through the diesel exhaust low point drain. Due to the large exhaust pipe diameter, it is not credible that any precipitation which collects and freezes, before it can pass through the drain line, will be sufficient to cause exhaust restriction. In addition, running of the diesel generator for availability testing will blow collected snow out of the exhaust. Therefore, clogging of the exhaust pipe with snow is not a problem.

The possibility of pipe whip does not exist in either emergency generator enclosure. All combustion air intake equipment and ductwork and the exhaust equipment and piping are seismically designed.

9.5.8.4 Inspection and Testing Requirements

The emergency generator combustion air intake and exhaust system is tested and inspected at the same time as the emergency generator set (Section 8.3.1.1.3).

9.5.8.5 Instrumentation Requirements

The emergency diesel combustion air intake and exhaust system operations parameters are monitored, indicated, recorded, and controlled as follows.

- The combustion air intake and exhaust system is available when the diesel engine is started.
- When air is drawn in through the filter and silencer, a manometer measures pressure drop.
- Red (running) and green (stopped) indicating lights are provided locally at the MCC for the emergency diesel engine crankcase vacuum pumps.
- Filter differential pressure is sensed by a differential pressure switch which actuates a high differential pressure alarm locally and a common trouble alarm in the control room.
- A pressure indicator is provided, locally, for inlet pressure to the diesel.
- An exhaust pyrometer is provided, complete with multicircuit selector switch and thermocouples for each exhaust, turbocharger nozzle, and common exhaust.

9.5.9 HYDROGEN AND NITROGEN STORAGE DISTRIBUTION SYSTEMS

9.5.9.1 Hydrogen System

The hydrogen system (Figure 9.5–5) supplies hydrogen to two components: the turbine generator (Figure 10.2–3) and the volume control tank (Figure 9.3–8). The hydrogen system is not safety-related.

9.5.9.1.1 Design Bases

The hydrogen system provides adequate hydrogen gas of suitable quality and pressure for plant hydrogen requirements.

To ensure reliability of the hydrogen supply system, a discharging stanchion serves as a fill connection and enables hydrogen to be supplied from a truck in the event of system malfunction in the hydrogen storage equipment.

A design temperature of 95°F for the hydrogen supply system is determined by ambient temperature extremes (0 to 86°F). Design pressure of the hydrogen supply system is 2,450 psig upstream, and 125 psig downstream, of the pressure control manifold.

The system and its components are designed for a plant life of 40 years.

9.5.9.1.2 System Description

The hydrogen supply system consists of one trailer discharging stanchion, one flammable grounding assembly, one pressure control manifold, one excess flow manifold, and 18 high pressure gaseous hydrogen storage tubes.

The 18 storage tubes are divided into two groups: 16 active and 2 reserve tubes. Hydrogen flows from the storage tubes to the pressure control manifold where it is reduced for plant use. The pressure regulators on the active and reserve tubes are at 105 and 90 psig, respectively. The reserve regulator, set to maintain 90 psig line pressure, is isolated during normal plant operations. This is meant to preclude reduction of reserve bank capacity during normal make up operations to the turbine generator since this operation may cause main header supply pressure to temporarily drop below 90 psig depending on the amount of product required for makeup. In the event of a sustained low main header pressure alarm, a manual valve may be opened to align the hydrogen system to the reserve bank. Table 9.5–5 lists the design parameters of the gaseous hydrogen storage tubes.

The following components are supplied by the hydrogen system.

1. The turbine generator (Section 10.2), which is cooled by the circulation of hydrogen at 75 psig, requires 39,700 scf for the initial purge and fill, plus make up for normal leakage.

2. The volume control tank system (chemical and volume control, Section 9.3.4) requires a maximum of 1 scfm of hydrogen continuously at 50 psig.

Relief valves are provided downstream of the high pressure storage tubes and pressure control manifold to prevent overpressurization of the equipment. Rupture discs are also provided on the high pressure storage tubes, located in the yard, for overpressure protection.

The hydrogen system is equipped with an excess flow manifold to ensure safety from a line rupture between the storage facility and the supplied components. The excess flow manifold has an excess flow valve which is designed to close at 6,500 scfh hydrogen flow, securing flow.

9.5.9.1.3 Safety Evaluation

The following provisions have been made to preserve an adequate hydrogen supply and ensure system reliability.

1. A trailer discharge stanchion is connected into the high pressure side of the pressure control manifold. This enables a tube trailer truck to be used as a source of gaseous storage or for recharging the storage vessels. A tube trailer grounding assembly has been provided to ground the tube trailers before discharge begins.

2. An excess flow manifold provides automatic isolation of the system in the event of a pipe rupture or excessive leakage.

3. All valves (except for check and control valves) located inside the building are of the sealed globe type to prevent the leakage of hydrogen gas. The pressure switches located inside the control cabinet are explosion-proof.

4. All hydrogen gas supply piping, located inside buildings, is either enclosed in steel guard piping (which is vented to the atmosphere), or designed to Seismic Category I, both provisions being in accordance with Branch Technical Position CMEB 9.5-1, Section C.5.d(5).

5. The hydrogen storage equipment is located in the gas storage area of the south yard (Figure 1.2–2). The hydrogen storage tubes are positioned such that an explosion of the tubes would direct them away from safety-related buildings and/or equipment. An eight foot high fence with a barbed wire top surrounds the area, and a flame barrier wall isolates the hydrogen storage tubes from the access road.

6. The following protective measures in the generator hydrogen and carbon dioxide system have been designed to prevent fires and explosions during filling, purging, and normal operation of the generator:

   - inert carbon dioxide is used for purging the air or hydrogen initially within the generator casing prior to being placed in service or opened for inspection or repairs;

   - a gas analyzer is provided at the outlet of the generator casing for constant indication of the percentages of air, carbon dioxide, and hydrogen present; and

   - the vent for the generator casing is shielded outside of the turbine building and is located to prevent accidental contact with discharge vapors, fire, sparks, high voltage lines, or vent intakes.

There are no safety-related components or equipment necessary for safe shutdown that require the operation of the hydrogen system.

9.5.9.1.4 Inspection and Testing Requirements

The hydrogen system is in continuous operation with essential system parameters continuously monitored and indicated by instrumentation; therefore, performance tests are not required. Inspection is performed in accordance with normal maintenance procedures.

9.5.9.1.5 Instrumentation Requirements

The hydrogen system operating parameters are monitored, indicated, and controlled, locally or remotely as follows.

1. The parameters monitored by local indicators are:

   - reserve hydrogen bank temperature;
   - active hydrogen bank temperature;
   - supply pressure to hydrogen supply to VCT pressure control valve;
   - hydrogen supply pressure;
   - hydrogen pressure to turbine generator hydrogen pressure regulator;
   - active hydrogen bank pressure;
   - reserve hydrogen bank pressure; and
   - reserve and active bank pressure regulator inlet and outlet pressure.

2. Annunciators on the main control board are alarmed when the following conditions exist:

   - hydrogen supply to VCT pressure low;
   - reserve hydrogen supply bank pressure low;
   - reserve and active banks pressure regulators outlet pressure low; and
   - active hydrogen bank pressure low.

9.5.9.2 Nitrogen System

The nitrogen system (Figure 9.5–5) supplies nitrogen to various components. The nitrogen system is not safety related; however, the containment isolation valves shown on Figure 9.5–5 and the connecting piping are Safety Class 2.

9.5.9.2.1 Design Bases

The nitrogen system is designed to provide adequate nitrogen gas of suitable quality and pressure for normal nitrogen requirements.

To ensure reliability of the nitrogen supply system, discharging stanchions are provided which enable nitrogen to be supplied from tube trailer supply trucks in the event of system malfunction in the nitrogen storage equipment.

Design temperatures of the nitrogen supply system have a maximum of 95°F resulting from extreme ambient conditions and a minimum of -320°F on the basis of the liquid nitrogen storage temperature. Design pressure of the nitrogen supply system varies and is dictated by the nitrogen users. Piping design pressures range from 2,450 to 200 psig.

The system and its components are designed for a plant life of 40 years.

9.5.9.2.2 System Description

The nitrogen supply system is comprised of three subsystems.

1. The high pressure nitrogen supply system includes one liquid nitrogen storage vessel, one high pressure liquid nitrogen pump, one high pressure ambient air vaporizer, six high pressure gaseous storage vessels, one high pressure control manifold, and one tube trailer discharging stanchion.

   Liquid nitrogen is pumped into the high pressure ambient air vaporizer where the liquid is vaporized into gas form. The gas then passes into the storage vessels which act as a surge volume for the pump during peak flow and provide a volume of high pressure storage. The liquid nitrogen pump starts automatically when the pressure in the gas storage vessels drops to 800 psig and shuts off when the storage pressure reaches 2,300 psig.

   For plant use, the pressure is reduced from gaseous storage pressure to 660 psig by the pressure control manifold which has been sized to allow a maximum flow of 3,000 scfh of nitrogen gas.

2. The low pressure nitrogen supply system consists of six low pressure ambient air vaporizers, one low pressure control manifold, and one tube trailer discharging stanchion.

   Liquid nitrogen is drawn from the storage vessel and flows to the low pressure ambient air vaporizers. Gas leaving the vaporizers flows to the pressure control manifold where the gas pressure is reduced to 185 psig for plant use. The pressure control manifold has been sized to allow a maximum flow of 18,000 scfh nitrogen gas.

3. The low pressure primary grade water tanks nitrogen supply system consists of one liquid nitrogen storage vessel, one low pressure ambient air vaporizer, two nitrogen blanketing control stations and two nitrogen sparging control stations.

   Liquid nitrogen flows from the vessel to the vaporizer. Gas leaving the vaporizer flows through a distribution manifold to a nitrogen blanketing control station and a sparging station located at each primary grade water tank. The system has been sized to allow maximum flow of up to 6,000 scfh nitrogen gas.

Table 9.5–6 gives the equipment being supplied by nitrogen, including the usage, pressure, and flow. Table 9.5–7 lists the major components of the nitrogen supply system and their design parameters.

A temperature indicating switch or a sensor and a temperature control valve located downstream of the high and low pressure ambient air vaporizers, respectively, activate when the temperature drops to -20°F. In the high pressure line, the pump is shut down by the temperature indicating switch; in the low pressure line, the temperature control valve closes. These actions prevent the vaporizers from icing up and protects downstream piping.

Relief valves are provided downstream of the high and low pressure vaporizers, high pressure storage tubes and high pressure liquid nitrogen pump to prevent overpressurization of the equipment. Relief valves are also provided around the liquid nitrogen storage vessel for overpressure protection and on the low and high pressure plant supplies to set the design pressure.

Both the low and high pressure supply systems are provided with tube trailer discharge stanchions to enable nitrogen to be supplied from tube trailer trucks in the event of liquid nitrogen storage and vaporization equipment malfunction.

The nitrogen line penetrating the containment structure contains air- operated containment isolation valves outside and inside the containment structure. The containment isolation valves and piping between them are Safety Class 2.

9.5.9.2.3 Safety Evaluation

The following provisions have been made to preserve an adequate nitrogen supply and ensure system reliability.

1. Tube trailer discharge stanchions are connected to both the high and low pressure subsystems. This enables a tube trailer truck to be used as a source of nitrogen in the event of a storage equipment malfunction.

2. Excess flow valves have been provided on subsystems 1 and 2 all system outlet lines to isolate the nitrogen supply in the event of a pipe rupture or excessive leakage.

3. Relief valves are provided throughout the nitrogen system to prevent overpressurization of the equipment.

9.5.9.2.4 Inspection and Testing Requirements

The nitrogen system operates continuously with essential system parameters continuously monitored and indicated by instrumentation. Performance tests are therefore not required. Inspection is performed in accordance with normal maintenance procedures. The containment isolation valves are tested in accordance with the procedures of Section 6.2.4.

9.5.9.2.5 Instrumentation Requirements

The nitrogen system operating parameters are monitored, indicated, and controlled, locally or remotely, as follows.

1. Control switches with position indicating lights are provided on the main control board for the nitrogen supply containment isolation valves. Containment isolation signals (CIA and CIB) automatically close both valves. Valve positions are monitored by the plant computer. An engineered safety feature status light is provided on the main control board to indicate when either of the valves are not closed.

2. Nitrogen storage tube low pressure is alarmed on the main control board.

3. Control switches are provided locally for the high pressure liquid nitrogen pump, and the following auto pump trips are identified by local indicator lights:

    - liquid nitrogen pump discharge gas temperature low;
    - liquid nitrogen pump discharge pressure high; and
    - liquid nitrogen pump cavitation high.

4. The following indicators are provided locally:

    - liquid nitrogen storage vessel pressure and level indicators;
    - nitrogen storage tubes temperature and pressure indicators;
    - low pressure nitrogen pressure indicator; and
    - high pressure nitrogen pressure indicator.

9.5.10 CONTAINMENT VACUUM SYSTEM

The containment vacuum system (Figure 9.4–5) establishes and maintains the reactor containment internal pressure at subatmospheric conditions during normal operations. The system is not safety-related, except for the portion of the system required for containment isolation.

9.5.10.1 Design Bases

The containment vacuum system is designed to perform the following functions.

1. Reduce the containment atmosphere pressure from atmospheric to subatmospheric conditions prior to plant startup.

2. Remove air from the containment atmosphere to maintain subatmospheric conditions, which compensates for containment structure air inleakage during normal operation.

3. Serve as a purge mode backup to the redundant hydrogen recombiner system for the control of combustible gas concentrations in the containment.

The only portions of the containment vacuum system which are safety- related (QA Category 1; Seismic Category 1) are the containment structure penetrations, the containment isolation valves, their controls (Ref. Figure 9.4–5 and Table 6.2–65) and the associated piping.

9.5.10.2 System Description

The containment vacuum system (Figure 9.4–5) consists of a containment vacuum ejector, two containment vacuum pumps, piping, valves, and instrumentation. The design data for the major components in the containment vacuum system are shown in Table 9.5–8.

The containment vacuum ejector removes air from the containment structure to create a subatmospheric pressure prior to initial unit operation and after subsequent refueling operations. The motive medium for the ejector is 135 psig saturated steam which is supplied at 14,000 pounds per hour from the auxiliary steam system (Section 10.4.10). The containment vacuum ejector discharges directly to the atmosphere through a silencer.

The containment vacuum pumps maintain the containment subatmospheric pressure and can be used to control containment hydrogen concentration. The common discharge of the two containment vacuum pumps is directed through the radioactive gaseous waste lines (Section 11.3) which are connected to the Millstone stack for elevated release. The system is not required to perform any safety related function. One of the vacuum pumps may be used for hydrogen concentration control. One pump draws air from the auxiliary building and discharges it into the containment while the second pump continues to remove air from the containment to the radioactive gaseous waste system.

Each containment vacuum pump is capable of removing containment structure air inleakage during normal operation and maintaining containment atmosphere pressure in the operating range of 10.6 to 14.0 psia.

9.5.10.3 Safety Evaluation

The containment vacuum pumps are operated remote manually from the control room to maintain containment atmosphere pressure at or below the maximum permissible value.

Operation of the containment vacuum system is not required for at least several weeks after a DBA; therefore, the system is not an engineered safety feature. This allows ample time for repair or replacement of containment vacuum system equipment, if necessary.

Excessive depressurization of the containment structure is not considered credible. The containment vacuum pumps have a relatively small capacity when compared to the containment structure free volume. Uninterrupted operation of a containment vacuum pump for approximately 11 days would be required to lower the containment atmosphere pressure from 9.0 psia to the minimum design pressure of 8.0 psia, assuming no air temperature change. The plant technical specifications require the operating pressure be above 10.6 psia.

The steam ejector is used for evacuating the containment from atmospheric pressure to subatmospheric pressure during startup operations, in approximately 4 hours, compatible with the normal startup schedule. Unit startup is performed in accordance with detailed written procedures, which include operation of the steam ejector system. The establishment of subatmospheric pressure in the containment is governed by administrative procedures and is closely supervised by personnel responsible for unit startup. Pressure indicators are located in the control room to provide the operator with a continuous indication of containment pressure. This close supervision and monitoring assure that the normal operating pressure is not reduced below that permitted by Technical Specification 3.6.1.4. In the unlikely event containment pressure is reduced below the value defined by the Technical Specifications, because of the slow rate of depressurizing the containment, there is sufficient time to take corrective action; i.e., take the ejector out of service. When the normal containment operating pressure is reached, the steam jet ejector is secured and locked out under administrative control and is not used during normal unit operation.

Continued operation of the ejector after establishment of the operating pressure is not considered credible because of the control room indication and administrative controls previously discussed.

The containment vacuum ejector is shut down when the containment atmosphere pressure operating range is reached, and a containment vacuum pump is started. At this time, the inside containment isolation valve on the containment vacuum ejector suction line is locked closed by means of a key-operated switch on the main control board, and the manual outside containment isolation valve is locked closed with a local lock. Therefore, excessive depressurization during initial operation of the ejector and inadvertent ejector operation during normal unit operation would be possible only with a violation of operating procedures and removal of the locking devices on the ejector suction valves. Although the containment vacuum ejector is normally operated from the auxiliary building, the suction valve switch ensures positive control of ejector operation by the operators in the control room.

The portion of the system that penetrates the containment is classified QA Category I along with the isolation valves that close on a CIA signal.

9.5.10.4 Inspection and Testing Requirements

The containment vacuum ejector is not required during unit operation, and because it is a simple mechanical device having no moving parts, periodic testing of the ejector is not required. The containment vacuum pumps are operated prior to fuel load to demonstrate adequate capacity to remove inleakage (Table 14.2–1, Preoperational Test No. 16). System design provides the capability to perform Type C testing as specified by Appendix J of 10 CFR 50.

9.5.10.5 Instrumentation Requirements

Containment air pressure instrumentation is part of the containment leakage monitoring system (Section 6.2.6). Details of this instrumentation are discussed in Section 7.6.7.

The containment vacuum pumps are manually activated from the control room and are interlocked with the two containment vacuum system isolation valves. When either isolation valve in a pump suction line is closed, the vacuum pump is stopped automatically. The containment vacuum system isolation valves close automatically on a Phase A containment isolation signal. The containment vacuum pumps are also stopped automatically by a pump discharge temperature signal greater than 280°F.

The containment vacuum system isolation valves have control switches and indicator lights on the main control board. Open and closed positions are monitored by the plant computer. Engineered safety feature status lights indicate on the main control board when an isolation valve is open.

The containment isolation valve for the vacuum system ejector suction is manually controlled from the main control board. The valve is provided with a keylock control switch and indicator light. The key can be removed only in the closed position.

Annunciators are provided on the main control board that alarm when the following conditions exist:

- Containment Vacuum Pump A - discharge temperature high;
- Containment Vacuum Pump B - discharge temperature high; and
- Any MCC load power not available (status lights on rear of main control board indicate which MCC is without power).

A local total flow indicator is installed in the combined discharge line for the containment vacuum pumps.

9.5.11 REACTOR COOLANT PUMP OIL COLLECTION SYSTEM

The reactor coolant pump (RCP) oil collection system incorporates enclosures having drip pans and splash guards at potential oil leakage sites to reduce the possibility of oil fires caused by ignition of oil leakage by hot RCS components and to maintain cleanliness of area.

9.5.11.1 Design Bases

The RCP oil collection system is designed in accordance with the following.

1. General Design Criteria 2 for structures housing the system and system components to withstand effects of natural phenomena such as earthquakes, tornadoes, and floods without loss of function.

2. Regulatory Guide 1.29 for the seismic classification of system components.

3. Paragraph C.7.a(1)(e) of BTP CMEB 9.5-1.

9.5.11.2 System Description

The RCP motor OSPS consists of a package of splash guards, drip pans, and enclosures assembled as attachments to the RCP motor at strategic locations. These enclosures do not interfere with RCP ventilation or bearing insulation, or the seal maintenance stand. Shroud enclosures are removable to facilitate maintenance.

The oil collected at the shroud enclosures is gravity drained to four oil collection tanks, one for each RCP. Each oil collection tank has a capacity of approximately 320 gallons and is vented to containment through a flame arrester/vent assembly. Removal of oil from the collection tank is accomplished via a hose connection on the tank and a portable pump.

The collection and control package consists of the following.

1. <u>Oil Cooler and Oil Cooler Piping Enclosure</u>

   The motor oil cooler has a number of flanged connections which represent potential sources of oil leaks. The entire oil cooler and connecting oil piping are therefore provided with an enclosure which collects any leaks which occur. This enclosure is designed to provide maximum access to the oil cooler through the use of multiple piece removable construction. Handles are provided as necessary for pieces which would be difficult to install and remove without them. Pieces are of such a size and configuration that they can be handled by one man without hoists or lifts. A drain suitable for draining the leakage oil is provided.

2. Upper Oil Level Alarm Enclosure

A drip pan is placed under the upper oil level alarm detector to collect any oil that may leak from the associated piping fittings. The pan has deep, removable sides to protect against atomizing of the leakage oil by the air currents around the motor. A viewing window is provided for reading the oil level sight glass. A drain connection is included.

3. Upper Oil Fill and Drain Pipe Enclosure

A drip pan is placed under the oil fill and drain valve to collect any leaks from the valve. The pan has deep, removable sides to protect against atomizing of the leakage oil by air currents around the motor. A drain connection is provided.

4. Upper RTD Conduit Box Enclosure

A drip pan is placed under the upper RTD conduit box. This pan also has deep, removable sides. A drain connection is provided.

5. Oil Lift System Enclosure

The oil lift system provides high pressure oil to the motor thrust bearings during startup. A leak in this system could result in oil being sprayed on hot system components. The oil lift system enclosure isolates the high pressure oil from the environment in the event that the system should leak during its operation.

The enclosure is designed to provide maximum access to the oil lift pump and motor through the use of multiple piece removable construction. A viewing window is provided in the enclosure. The pieces of the enclosure are of a size and configuration such that they can be handled by one man without hoists and lifts. Handles are provided where appropriate. A drain connection is provided.

6. Lower Bearing Oil Pot Drip Pan

This catch basin is located immediately below the lower bearing oil pot and is removable. The pan surrounds the shaft and extends to the lower bracket edge thus protecting the entire underside of the lower oil pot.

7. Upper Bearing Oil Pot Drip Pan

This catch basin is an integral part of the upper bracket. It surrounds the shaft and would catch oil which might come over the standpipe. A drain connection runs to a point external to the upper bracket.

9.5.11.3 Safety Evaluation

There are no moving parts where failure could jeopardize system function in the oil collection system.

Earthquakes and fires are the only natural and postulated phenomena which might affect the operation of this system. The RCP oil collection system is seismically supported.

9.5.12 REFERENCES FOR SECTION 9.5

9.5-1 Albertson, M.L., Dai, Y.B., Jensen, R.A., and Rouse, H. Diffusion of Submerged Jets. Trans. ASCE, Vol 115. 1950.

9.5-2 Colt Industries Fairbanks Morse Engine Division, P.O. No. 2447. 300-241, MP3 Vendor Factory Diesel Air Test Reports.

9.5-3 Harleman, D.R.F. Section 26--Stratified Flow. From Handbook of Fluid Dynamics. Ed. V.L. Otruter. 1969.

TABLE 9.5–1 COMPLIANCE WITH FIRE PROTECTION TECHNICAL REQUIREMENTS

Refer to the Fire Protection Evaluation Report, Appendix B.

TABLE 9.5–2 EMERGENCY DIESEL GENERATOR COOLING WATER SYSTEM LEAKAGE SUMMARY PER DIESEL*

	JACKET WATER SYSTEM	
	(gph)	**(gal/30 days)**
Piping and Valves	0.02	14.4
Pump Seal	0.06	43.2
Turbochargers and Piping	0.01	7.2
Orifices, Gasketed both sides	0.00	0.0
Instrumentation	0.00	0.0
Subtotal (Jacket Water System)	0.09	64.8
	INTERCOOLER WATER SYSTEM	
	(gph)	**(gal/30 days)**
Piping and Valves	0.03	21.6
Pump Seal	0.06	43.2
Instrumentation	0.00	0.0
Subtotal (Intercooler Water System)	0.11	64.8
TOTAL (Jacket and Intercooler Water Systems)	0.20	129.6

NOTE:

* Leakage rates are provided by the diesel generator manufacturer

* Operators can manually provide make up to the Jacket Water Expansion Tank after 24 hours. The acceptable leak rate for 24 hours is 6 GPH.

TABLE 9.5–3 DESIGN DATA FOR MOTOR COMPONENTS IN EMERGENCY GENERATOR COOLING WATER SYSTEMS

COMPONENT	DESIGN PRESSURE (psig)	FLOW CAPACITY (gpm)	TEMPERATURE DIFFERENTIAL (°F)	DESIGN HEAT REMOVAL RATE (Btu/hr)	HEAT REMOVAL RATE REQUIRED AT 5335 kW DG RATING (Btu/hr)
PUMPS					
Jacket Water Engine Driven Pump	57	880	---	---	---
Jacket Water 460 V Motor-Driven Circ Pump	10	60	---	---	---
Intercooler Water Engine-Mounted Pump	57	880	---	---	---
HEAT EXCHANGING EQUIPMENT: JACKET WATER SYSTEM					
Cylinder Liner Jackets and Turbochargers	---	---		6,781,000	
Lube Oil Cooler	150	913 (normal)	3.6	1,638,000	
Governor Lube Oil Cooler				≈ 0	
				Total: 8,419,000	
Jacket Water Heat Exchanger	150	913 (shell) 1900 (tube)	18.5 (shell) 8.9 (tube)	8,419,000	8,235,000
INTERCOOLER WATER SYSTEM					
Intercooler Water Heat Exchanger	150 (tube/shell)	800 (shell) 1900 (tube)	10.8 (shell) 4.6 (tube)	4,338,055	4,045,000

<u>NOTE</u>: Jacket water and intercooler water heat exchangers were sized at 110% diesel generator load (5486 kW).

TABLE 9.5–4 DESIGN DATA FOR THE MAJOR COMPONENTS OF EMERGENCY GENERATOR - DIESEL LUBRICATING OIL SYSTEM

Component	Design Pressure (psig)	Flow Capacity Each (gpm)	Temperature Differential (°F)	Design Heat Removal Rate (Btu/hr)
Lubricating Oil Heat Exchanger	150	475 (shell)	15.4 (shell)	1,638,000
Lube Oil Heater	120	50	-	51,194 (design heat duty)
PUMPS:				
Lubricating Oil Pump	100 (normal)	400 (normal)	-	-
Rocker Arm Lubricating Oil Pump	20 at 514 rpm	2.2	-	-
Prelubricating Oil Filter Pump	100	50	-	-
Rocker Arm Pre-Lube Oil Pump	50 (discharge)	2	-	-

NOTE:

Each component has approximately 12 percent additional capacity (margin).

TABLE 9.5–5 GASEOUS HYDROGEN STORAGE TUBES

Design Parameter	Value
Number of active tubes	16
Number of reserve tubes	2
Volume of each tube (ft^3)	51.1
Maximum storage pressure (psig)	2,300
Tube test pressure (psig)	3,675
Storage capacity (1 tube) of gaseous hydrogen between 100 psig and 2,300 psig (scf) at 95°F	6,935
Rupture disk rupture pressure (psig)	3,307
Design temperature (°F)	95

TABLE 9.5–6 EQUIPMENT SUPPLIED BY THE NITROGEN SYSTEM

	Equipment	Section Reference	Usage	Pressure (psig)	Flow
1.	Main steam isolation trip valves	10.3	Intermittent	185	Negligible
2.	1st, 2nd, 3rd, 4th point feedwater heaters**	10.4.2	Intermittent	185	15 scfm/heater
3.	Auxiliary boilers	10	Intermittent	5	50 scfm/boiler
4.	Hot water expansion tank	9.2.6	Continuous	120	67 scf/day to leakage
5.	Main steam system	10.3	Intermittent	5	50 scfm/loop
6.	Safety injection accumulator tanks	6.3	Intermittent	660	3,000 scfh
7.	Process gas precooler	11.3	Intermittent	5	200 ft^3 total
8.	Process gas charcoal bed adsorbers	11.3	Intermittent	5	4,000 ft^3 total for purging
9.	Process gas degasifier	11.3	Intermittent	5	4,000 ft^3 total for purging
10.	Process gas compressor prefilter	11.3	Intermittent	5	3 ft^3 total for purging
11.	Volume control tank	9.3.4.2.5	Intermittent	185	400 ft^3 for purging
12.	Reactor plant gaseous drains	9.3.5	Continuous	5	480 scf/day (total)
13.	Reactor plant gaseous vents	9.3.5	Continuous	3	7 scfm/vent
14.	Steam generator blowdown	10.4.6	Intermittent	5	50 scfm/sg
15.	Pressure relief tank	5.4.11	Continuous	2	508 scf/day
16.	Chilled water expansion tank *	9.2.2	Intermittent	7	10 scf/day to leakage
17.	Condensate storage tank	9.2.6	Continuous	<.75	9,380 scfh maximum
18.	Condensate surge tank	9.2.6	Continuous	<.75	39,135 scfh maximum
19.	Primary grade water storage tanks	9.2.8	Continuous	0.5 In. Wtr.	5,805 scfh maximum

* Supplied by separate nitrogen bottle.
** Nitrogen not supplied to “A” and “B” 4th point feedwater heater.

TABLE 9.5–7 NITROGEN SYSTEM MAJOR COMPONENT DESIGN DATA

I. High Pressure Nitrogen Supply System and Low Pressure Nitrogen Supply System (Subsystems 1 and 2)

Component	Value
Cyrogenic Liquid Storage Vessel	
Net liquid capacity (gal)	3,082
Net gas equivalent capacity (scf)	287,000
Maximum working pressure (psig)	245 at 150°F
Design temperature (°F)	-320 to 150
Operating temperature (°F)	-320
Liquid Nitrogen Pump	
Design flow (gpm)	1.79
Pump speed (rpm)	250
Motor design (hp)	10
Low Pressure Ambient Air Vaporizers	
Number of vaporizers	6
Design temperature (°F)	-425 to 150
Maximum allowable working pressure (psig)	300
Capacity (scfh)	3,000
Test Pressure (psig)	375
High Pressure Ambient Air Vaporizer	
Number of vaporizers	1
Design temperature (°F)	-425 to 100
Maximum allowable working pressure (psig)	3,000
Capacity (scfh)	10,000
Test Pressure (psig)	4,500
High Pressure Gaseous Storage Tubes	
Number of tubes	6
Volume of each tube (ft^3)	51.1

I. High Pressure Nitrogen Supply System and Low Pressure Nitrogen Supply System (Subsystems 1 and 2)

Component	Value
Maximum storage pressure (psig)	2,300
Tube test pressure (psig)	3,675
Total storage capacity of gaseous nitrogen between 660 and 2,300 psig (6 tubes) (scf)	35,139

II. Primary Grade Water Tanks Nitrogen Supply System

Component	Value
Cryogenic Liquid Storage Vessel	
Net liquid capacity (gal)	1,490
Net gas equivalent capacity (scf)	138,400
Maximum working pressure (psig)	250
Operating pressure (psig)	155 to 165
Design temperature (°F)	-320 to 100
Operating temperature (°F)	-320
Low Pressure Ambient Air Vaporizer	
Number of vaporizers	1
Design temperature (°F)	-425 to 160
Maximum working pressure (psig)	500
Capacity (scfh)	8,000
Nitrogen Blanketing Control Station	
Number of stations	2
Maximum capacity per station (scfh)	5084
Supply pressure (psig)	150
Control pressure range (inches of water)	1/4 to 3/4

TABLE 9.5–8 DESIGN DATA FOR MAJOR COMPONENTS IN THE CONTAINMENT VACUUM SYSTEM

Component	Design Operating Pressure (psia)	Design Capacity (1) (Each)
Vacuum ejector		
Suction	14.5	16,575 lb/hr
Discharge	15.0	
Vacuum pump		
Suction	9.7	108 cfm
Discharge	16.06	(66 scfm) (1)

NOTES:

1. At 9.5 psia, dry air, 90°F
2. At standard conditions (14.69 psia, dry air, 60°F)

TABLE 9.5–9 EMERGENCY GENERATOR AUXILIARY SYSTEM COMPONENT CHARACTERISTICS

Crankcase Vacuum Pump		
	Power Source	Train A Bus 32-1T (1)
		Train B Bus 32-1U (1)
	Horsepower	1 hp
	Voltage	460 V
	Phase	3
	Frequency	60 Hz
	Pump Capacity	630 sfcm
	Discharge Head	1.2 inches water
Standby Jacket Coolant Heater (i.e., Electric Immersion Heater)		
	Power Source	Train A Bus 32-1T (via 3EGS*PNL1A) (1)
		Train B Bus 32-1U (via 3EGS*PNL1B) (1)
	kW Output	18 kW
	Voltage	480 V
	Phase	3
Standby Jacket Coolant Pump (i.e., Motor-Driven Water Circulating Pump)		
	Power Source	Train A Bus 32-1T (via 3EGS*PNL1A) (1)
		Train B Bus 32-1U (via 3EGS*PNL1B) (1)
	Horsepower	1 hp (3EGS*P2A) (3EGS*P2B)
	Voltage	460 V
	Phase	3
	Frequency	60 Hz
	Pump Capacity	60 gpm
	Discharge Head	22 ft TDH
Emergency Generator Air Compressor (i.e., Motor-Driven Air Compressor)		
	Power Source	Train A Bus 32-1T (two compressors) (1)
		Train B Bus 32-1U (two compressors) (1)
	Horsepower	15 hp

TABLE 9.5–9 EMERGENCY GENERATOR AUXILIARY SYSTEM COMPONENT CHARACTERISTICS (CONTINUED)

	Voltage	460 V
	Phase	3
	Frequency	60 Hz
DC Fuel Oil Pump		
	Power Source	Train A Bus 301A-1 (via 3BYS*PNLDG1F) (2)
		Train B Bus 301B-1 (via 3BYS*PNLDG2F) (2)
	Horsepower	2 hp
	Voltage	90-140 V dc
Fuel Oil Transfer Pump		
	Power Source	Train A Bus 32-1T (two pumps) (3)
		Train B Bus 32-1U (two pumps) (3)
	Horsepower	3 hp
	Voltage	460 V
	Phase	3
	Frequency	60 Hz
	Pump Capacity	40 gpm
	Discharge Head	65.5 ft of oil
Rocker Arm Prelube Oil Pump		
	Pump Source	Train A Bus 32-1T (via 3EGS*PNL1A) (1)
		Train B Bus 32-1U (via 3EGS*PNL1B) (1)
	Horsepower	0.5 hp
	Voltage	460 V
	Phase	3
	Frequency	60 Hz
	Pump Capacity	2 gpm
	Discharge Head	50 psi
Prelubrication and Filter Pump		
	Pump Source	Train A Bus 32-1T (via 3EGS*PNL1A) (1)
		Train B Bus 32-1U (via 3EGS*PNL1B) (1)

TABLE 9.5–9 EMERGENCY GENERATOR AUXILIARY SYSTEM COMPONENT CHARACTERISTICS (CONTINUED)

	Horsepower	7.5 hp
	Voltage	460 V
	Phase	3
	Frequency	60 Hz
	Pump Capacity	50 gpm
	Discharge Head	Built-in relief valve set at 120 psig
Prelube Oil Heater (i.e., Electric Heater)		
	Power Source	Train A Bus 32-1T (via 3EGS*PNL1A) [1]
		Train B Bus 32-1U (via 3EGS*PNL1B) [1]
	kW Output	15 kW
	Voltage	480 V
	Phase	3

NOTES:

1. Refer to Section 1.7, Drawing 12179-EE-1AK
2. Refer to Section 1.7, Drawings 12179-EE-1BB and 1BC
3. Refer to Section 1.7, Drawing 12179-EE-1AK and Section 8.3, Figure 8.3–6

TABLE 9.5–10 COOLING WATER SYSTEM LEAKAGES

Type of Leakage	Means Used to Detect	Corrective Measures	Permissible Inleakage or Outleakage
1. Jacket water into lube oil system (standby mode)	a. Visual inspections of lube oil sump tank (abnormal level) and color of oil (greyish of yellow-brownish tint if water is polluted)	Repair cooler leakage and clean	Lube oil water content of 0.5 percent maximum
	b. Periodic testing of the lube oil quality		
2. Lube oil into the jacket water system (operating mode)	a. Periodic testing of the jacket water quality	Repair cooler leak and clean	Any significant lube oil leakage which results in visual detection in expansion tank sight glass
	b. Visual inspection of expansion tank water		
3. Jacket water into the engine air intake and governor systems (operating or standby mode) lube oil	a. Visual inspection of turbocharger jackets	Repair defective turbocharger or governor lube oil cooler	Lube oil water content of 0.5 percent maximum
	b. Periodic testing of the governor lube oil quality		
4. Jacket water/service water systems	a, Periodic testing of the jacket water quality	Repair tank in jacket water cooler or engine air cooler water heat exchanger	Any leakage which results in exceeding manufacturer's water quality limits
	b. High level in the expansion tank		

FIGURE 9.5–1 FIRE PROTECTION SYSTEM (NOW IN FPER FIGURE 4-1)

THIS FIGURE NOW IN FIRE PROTECTION EVALUATION REPORT Figure 4-1

FIGURE 9.5–2 P&ID EMERGENCY GENERATOR FUEL OIL SYSTEM

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.5–3 P&ID EMERGENCY DIESEL RELATED SYSTEMS (SHEETS 1-5)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.5–4 FIRE PROTECTION SYSTEM (NOW IN FPER FIGURE 4-1)

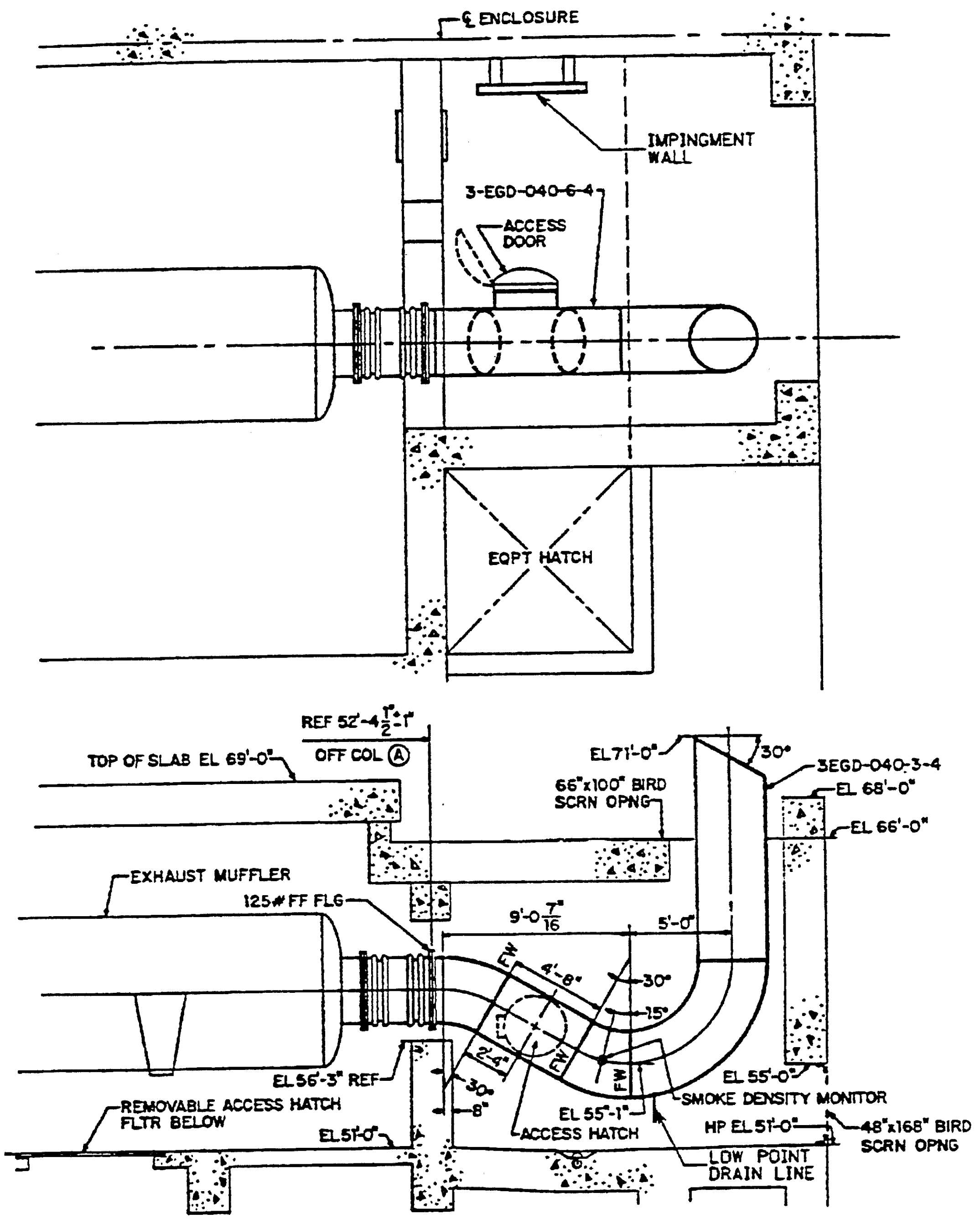


FIGURE 9.5–5 P&ID NITROGEN AND HYDROGEN SYSTEM (SHEETS 1-3)

The figure indicated above represents an engineering controlled drawing that is Incorporated by Reference in the MPS-3 FSAR. Refer to the List of Effective Figures for the related drawing number and the controlled plant drawing for the latest revision.

FIGURE 9.5–6 NOT USED

FIGURE 9.5–7 SITE WATER FIRE PROTECTION