9.1 SERVICE WATER SYSTEM

9.1.1 DESIGN BASIS

The Service Water System is designed to supply lake water as the cooling medium (Ultimate Heat Sink) for removal of waste heat from the nuclear plant and steam plant auxiliary systems during normal, shutdown or emergency conditions. Separate service water lines serve the Plant critical and noncritical systems. The critical system is divided into two electrically independent trains that provide equivalent cooling, which are CP Co Design Class 1. The service water pumps are located in the CP Co Design Class 1 portion of the intake structure. The service water piping within the containment building is protected from internally generated missiles by the fact that they are outside of the primary coolant system shield.

9.1.2 SYSTEM DESCRIPTION AND OPERATION

9.1.2.1 System Description

Three half-capacity electric motor-driven pumps draw screened and intermittently chlorinated Lake Michigan water from the intake structure (Figure 9-1). Two motors are connected to one 2.4 kV bus and the third motor is connected to a separate 2.4 kV bus. Each pump can be started or stopped remotely from the main control room or locally at the switchgear.

Each service water pump discharges through a simplex strainer into a common header. Each pump can be isolated from this header by a manually-operated valve in the pump discharge.

The common header of the service water pumps has a full-capacity takeoff at each end which supplies critical Plant systems. A third takeoff at one end of the common header supplies the noncritical auxiliary systems. The common header contains sectionalizing valves which can be closed from the main control room if isolation of a portion of the service water supply system is required.

The two critical service water lines run underground by different paths from the intake structure to the auxiliary building. The two lines are joined in the auxiliary building by a double-valved crosstie. Each line has an isolation valve upstream of the crosstie valves. These four valves permit the isolation of either critical line. Each valve is a fail open, piston-operated type and can be actuated remotely from the main control room or manually by a local handwheel.

Upstream of the crosstie valves, each line supplies cooling water to one set of the redundant components including emergency diesel generator lube oil and jacket water coolers, a control room air-conditioning unit, an air compressor after-cooler and an engineered safeguards room cooler. In addition, Train A supplies cooling water to the component cooling water heat exchangers while Train B supplies cooling water to the containment air coolers.

The service water discharge from equipment carrying potentially contaminated fluid is continuously monitored for radioactivity, enabling radioactive leakage into the service water to be detected before service water is released to the lake.

Provisions are made to connect the fire system to the Service Water System as a partial backup.

Provisions exist to replenish the Spent Fuel Pool (SFP) from the Service Water System when SFP inventory is used to supply makeup to the Primary Coolant System via the charging pumps if the Safety Injection Refueling Water (SIRW) Tank is unavailable (see Section 1.8.5).

Systems supplied by the Service Water System and cooling water flow requirements for equipment supplied by the Service Water System are tabulated in Table 9-1.

In response to Generic Letter 89-13, a program was established to address the issue of biofouling of the service water system. Elements of this program include periodic inspections of the service water pump intake bay and service water system components, chlorination of service water, periodic flushing of infrequently used cooling loops and periodic verification of service water system flow rates and heat exchanger heat transfer capabilities (see Reference 6).

See Reference 9.12, Ultimate Heat Sink, for additional information for design and inspection of structures and components associated with the Ultimate Heat Sink.

9.1.2.2 Component Description

Design ratings of components in this system are given in Table 9-2.

9.1.2.3 System Operation

1. Normal Operation

   Two service water pumps are required to furnish the normal cooling water demand; the third pump will normally be on standby. Two pressure switches are provided in the discharge of each pump connecting to the starting circuits of the remaining two pumps. If the service water pressure falls below a preset value, one of the switches initiates automatic starting. The auto-start feature is automatically reset on bus undervoltage to prevent cycling the pump breaker onto a dead bus.

2. Shutdown Operation

   Service water flow requirements during shutdown cooling will remain essentially the same as for normal operation. This is due to the fact that there are no significant heat loads on the non-critical header, but service water flow to the CCW heat exchanger increases significantly while on shutdown cooling. Both component cooling water heat exchangers are used to cool the primary coolant from 300°F to the refueling temperature. Service water flow is maintained to equipment on an as-needed basis (eg, FWP air compressors, containment air coolers.)

3. Post-DBA Operation

   Either one or two service water pumps are required to provide cooling in the event of a DBA, depending on the accident events. If Plant offsite power sources are lost, all pump motors are automatically supplied with power from the emergency diesel generators with one pump on Diesel 1-1 and two pumps on Diesel 1-2. Cooling water demands can be met with one pump if only Diesel 1-1 is operating provided service water to containment is isolated, and with two pumps if only Diesel 1-2 is operating.

   Service water through most noncritical systems is terminated by automatic closure of the noncritical header shutoff valve on a Safety Injection Signal (SIS), thus ensuring that all available service water is routed to the critical systems. The automatic shutoff valve can also be actuated remotely from the main control room or by a local handwheel. This does not isolate all non-critical loads; instrument air compressors C-2A and C-2C aftercoolers are on critical service water headers B and A, respectively, and are not isolated because their service water requirements are not significant (see Table 9-1).

On loss of instrument air, the service water high capacity outlet valves from the CCW heat exchangers fail open, while the bypass valves fail closed to conserve service water. Hard stops are placed on the high capacity outlet valves to prevent them from going full open and starving other critical services. Service water is continued to all critical systems' heat exchangers.

Engineered safeguards pumps seal cooling is normally provided from the Component Cooling System; however, if that system is not operable, the Service Water System can be aligned for seal cooling.

The Service Water System is tested periodically (Reference 32) to determine the flows to equipment on the critical headers. The system is aligned as it would be following a DBA coincident with a loss of offsite power, loss of a diesel generator, and a loss of instrument air.

The maximum allowed service water temperature was determined by analysis to be 81.5 °F. The service water temperature has exceeded 81.5°F on one occasion since 1982 for a very short duration (less than 4 hours). The NRC issued an SER in 1987 (Reference 8) that recognized the possibility of elevated SW temperatures, but concluded that the likelihood for the incident of concern occurring was negligibly low. That incident being a DBA LOCA, loss of offsite power, loss of a diesel generator, plant at power, and Service Water inlet temperature above 80°F. Now, the maximum temperature is 85°F making it even less likely for the event to occur. At that time the NRC also recognized that the time periods of elevated lake temperature are shorter than the time required to complete an action statement and therefore required no Technical Specification limit on ultimate heat sink temperature. However, as part of the conversion to Improved Technical Specifications, Amendment 189 added an Ultimate Heat Sink LCO to the Technical Specifications which prohibits plant operation with service water (ultimate heat sink water) temperature above the limit.

Even in the unlikely event that the incident of concern should occur the operators monitor SW system header pressure. If the header pressure reaches a predetermined low pressure corresponding to low flows to the various components the operators are procedurally instructed to restore service water and if necessary can align the Fire System to the Service Water System and start a fire pump. This latter action increases the flows to the critical components by approximately 10% as shown by past testing. (Reference 32) This additional flow ensures that each component is capable of performing its design function for Service Water temperatures well in excess of any lake temperature ever measured.

Subsequently, additional analyses and testing have been performed to determine the response to a Loss-of-Coolant Accident at increased service water temperatures. The analyses assumed a service water temperature of 85°F to bound any future increase in lake temperature. This evaluation confirmed that adequate heat removal would be provided by the service water system for lake temperatures up to 85°F, and was used to support a change to Technical Specifications (References 33 and 44).

After Standard Technical Specification issuance in the year 2000, the temperature limit of 81.5°F was found to incorporate too little margin to accommodate instrument uncertainty requirements at historically observed maximum Lake Michigan shoreline water temperatures. An Improved Technical Specifications operability limit increase to 85°F was requested and received. After replacement of TI-1319, which is used to monitor the ITS limit within 1.5°F uncertainty, the 85°F limit accommodates the maximum historically observed plant intake water temperature with reasonable margin.

9.1.3 DESIGN ANALYSIS

9.1.3.1 Margins of Safety

System reliability is achieved with the following features:

1. Each of the three service water pumps is capable of supplying 50% service water during normal, shutdown and post-DBA conditions.

2. Pump motor power is normally supplied from offsite sources with backup from the emergency diesel generators.

3. Electrically independent service water trains that provide equivalent cooling supply critical systems. Loss of one header does not compromise Plant safety.

4. The fire pumps can be valved into the critical service water header thereby serving as a partial backup to the Service Water System.

9.1.3.2 Provisions for Testing and Inspection

Components of the Service Water System outside the containment building and above ground are accessible for periodic inspection during Plant operation.

All components inside the containment building are accessible after Plant shutdown and some are accessible during plant operation. This system is always in operation, but each service water pump can be periodically tested for auto-start. After start-up, the piping is subject to the inservice inspection requirements of the ASME Boiler and Pressure Vessel Code, Section XI.

9.1.3.3 Discharge Line Rupture Analysis

The critical service water piping system consists of two main supply lines; one serving the component cooling heat exchangers, one serving the containment air coolers. The discharge from all service water loads is eventually returned to a single common discharge line that splits into two separate piping runs before tapping into the cooling tower makeup basin. Each supply line also serves equipment comprising the minimum engineered safeguards for post-DBA cooling. The supply system is provided with valves to permit isolation of either of the main supply lines in the event of pipe failure.

The discharge piping system consists primarily of a 16-inch line from the containment air coolers and a 24-inch line from the component cooling heat exchangers. These two discharge lines are joined into a single 24-inch discharge line in the west engineered safeguards room. After the single 24-inch discharge line receives the service water from the engineered safeguards pumps seal coolers, and the engineering safeguards room air coolers, the line is run underground to the discharge structure. The remaining service water loads, including the emergency diesel generator lube oil and jacket water coolers, control room HVAC, instrument air compressor aftercoolers, auxiliary building air-conditioning condensers and noncritical equipment return headers are discharged into a common 16-inch header. This header runs underground from the lube oil room to join the common 24-inch discharge return line that is routed to the cooling tower makeup basin.

The containment air coolers 16-inch discharge line leaves the containment at elevation 611 feet 10 inches, turns down into the west engineered safeguards room through the component cooling equipment room floor at elevation 590 feet 0 inches and joins the 24-inch line from the component cooling heat exchangers. The single 24-inch discharge line is approximately 3 feet long in the west room. The single discharge line leaves the west room at elevation 579 feet 0 inches and is routed underground directly to the cooling tower pump suction/discharge basin at elevation 583 feet 0 inches, where it splits into two separate lines before tapping into the basin.

Failure of the individual branch lines beyond their isolation valves and the single line have been analyzed to determine that failure in any part of the discharge piping will not result in significant flooding above the 590-foot floor. The amount of flooding has been based on the following:

1. Continuous spillage from a failure in a branch line will be backflow only. The supply can be valved off by closing the associated branch line valves.

2. Backflow through a ruptured branch line or spillage from the single line will be terminated at a water depth above the discharge elevation, of 583 feet, equal to the friction loss for the appropriate flow through the discharge line to discharge structure. The maximum friction loss and thus the maximum flood level occurs when the flow through the discharge line is the greatest.

With a service water spillage flow rate of 16,386 gpm, a postulated slot rupture in the single 24-inch discharge line would result in a flood level elevation of 590 feet (Reference 12). However, since the Service Water System is, by definition, a moderate-energy system, only a critical crack need be postulated to occur in this piping, rather than a slot break, per Section 5.6.1. With that being the case, the postulated flow rate noted above is more than two orders of magnitude greater than what is required to be considered, thus limiting the spillage flow rate into the room from a pipe crack in this system downstream of the isolation valves.

All miscellaneous critical equipment connected to the common discharge line is provided with block valves in the individual discharges and can be isolated if required. The individual discharge lines are small and do not represent a potential large flooding source except for the emergency generators. These lines are each six inches, they do not penetrate the dividing wall, and the outlet block valves have been located outside of the generator rooms so that backflow through a rupture line associated with one generator will not enter the second generator room.

9.1.3.4 **Generic Letter 96-06 Waterhammer Analysis**

The NRC issued Generic Letter 96-06 (Reference 51) that required plants to address the functionality of plant components under Design Basis Accident conditions. The primary thrust of this effort evolved in to a waterhammer assessment of the service water system as affected by a combination of Loss of Offsite Power with Loss of Coolant Accident or Main Steam Line Break conditions. The service water system configuration and containment air cooler performance characteristics under these loading combinations were investigated in order to identify bounding analyses that would provide an assessment of the structural integrity of the service water system and its associated components. The industry sought EPRI and expert assistance in providing guidance in order to formulate an analysis/test plan to ascertain the capability of the service water system to sustain these loads. The EPRI guidance was provided in References 53 and 54, which subsequently was formally endorsed by the NRC in Reference 55.

Sargent and Lundy Report SL-008300 was prepared in accordance with the EPRI guidance to resolve the issue. That report is included as an attachment to EA-GL-96-06-SWS-02 (Reference 52). The assessment includes the event scenario in which the plant loses offsite power, the service water system in containment temporarily loses pressure, boiling subsequently takes place in the containment air coolers generating an air/steam void in the coolers, the service water pumps restart and supply water to the coolers, the void is compressed between the advancing service water refill flow and the containment air cooler return flow, the void consequently shrinks due to steam condensation, the supply and return water columns collide, and a pressure wave is transmitted through the system at the speed of sound in the fluid medium.

The unbalanced forces from the hydraulic transient were incorporated into a piping system structural analysis to evaluate the critical service water piping, pipe supports, and associated components, including those associated with the containment air coolers. Waterhammer loads were employed in a faulted load case and incorporated into a load combination in place of the safe shutdown earthquake.

The report concluded that the affected piping and pipe supports met FSAR design criteria and no structural modifications were required.

9.2 REACTOR PRIMARY SHIELD COOLING SYSTEM

9.2.1 DESIGN BASIS

The reactor Shield Cooling System is designed to remove heat from the biological shield surrounding the reactor vessel thereby limiting the thermal stresses in the structural concrete. It is not a safety-related system and was designed to CP Co Design Class 3 standards.

The system is designed to maintain structural concrete temperature below 165°F. The system is to assure that the concrete in the reactor cavity does not overheat and develop excessive thermal stress. One shield cooling pump and one set of cooling coils will be in operation whenever cooling is required to maintain the temperature of the concrete below approximately 165°F. The system is capable of removing 180,000 Btu/h. During normal Plant operation, the total heat load in the concrete is 120,000 Btu/h. This heat load consists of 85,000 Btu/h of convective and radiative heat losses from the reactor and 35,000 Btu/h of nuclear heat generated in the shield from the interaction of gamma rays and neutrons with the concrete.

9.2.2 SYSTEM DESCRIPTION AND OPERATION

9.2.2.1 System Description

The Shield Cooling System is a closed loop system consisting of two full-capacity sets of cooling coils, two full-capacity pumps, a heat exchanger, a surge tank, associated piping, valves, instrumentation and controls as shown on Figure 9-2.

All components of the system are located within the containment building.

Each set of shield cooling coils is composed of individual cooling coils embedded in the concrete shield. The distance between the inner surface of the concrete and center line of cooling coils is three inches.

The supply header to each set of cooling coils is provided with a diaphragm-operated, fail-open valve operated from the main control room. A check valve is provided in the discharge header for each set of coils to prevent flow from the coils in service into the coils which are out of service.

The closed loop system transfers heat to the Component Cooling Water System by means of the shield cooling heat exchanger. Demineralized water with a corrosion inhibitor is used in the shield cooling loop.

9.2.2.2 Component Description

Design ratings and design features of components of the system are given in Table 9-3.

9.2.2.3 System Operation

1. Normal Operation

During normal operation, one shield cooling pump and one set of cooling coils are in continuous service. The idle pump is in standby. The normal flow through the shield cooling coils is from 134 to 154 gpm. The shield cooling heat exchanger is in continuous service with the shield cooling water flowing through the tubes and component cooling water through the shell.

Both pumps can be started and stopped from the main control room. The standby pump starts automatically on low discharge header pressure.

The surge tank is installed at elevation 649 feet 0 inches in order to maintain an approximately constant suction head of 27 psig on the pumps. Makeup water to the tank is normally pumped from the primary system makeup storage tank through an on-off solenoid valve which is actuated by a level switch on the surge tank. The condensate storage tank can be used as an alternate makeup supply. High and low level in the tank is annunciated in the control room. The tank vents directly to the containment atmosphere and this protects the tank from overpressurization.

The temperature of the shield cooling water is regulated by manual adjustment of the component cooling water outlet header butterfly valve.

Temperature indication, high temperature (120°F) and low flow annunciation from the discharge of each set of coils are located in the control room. If the cooling coil set in operation becomes inoperative, the standby set is brought into operation by opening the inlet header control valve manually from the control room. Both pumps can supply cooling water to either set of coils.

The shield cooling system is used to maintain the structural concrete temperature below 165°F, thus preventing weakening of the structure through loss of moisture. The structure must remain intact during a DBA to preclude damage to the reactor building sump and the plugging of the suction lines to the engineered safeguards pumps. One pump and one set of cooling coils is more than adequate to remove the 120,000 Btu/hr heat load at Rated Power operation. The capacity of the reactor cavity concrete to sustain temperatures greater than 165°F is discussed in Reference 23.

The steady-state temperature profiles (Reference 27) used in the design of the primary shield during normal operating condition and design basis conditions are shown in Figures 9-3 through 9-6.

2. Shutdown Operation

During hot reactor shutdown conditions, the operation of the system is the same as during normal operating conditions.

The temperature profiles in the primary shield are similar to those during normal operating conditions.

During cold shutdown of the reactor, one shield cooling pump will continue to operate during the initial hours. Subsequently, as the reactor temperature decreases to a point such that the resultant temperature to the shield concrete remains below approximately 165°F without cooling, the shield cooling pump can be stopped manually.

3. Post-DBA Operation

The cooling system is not required after a DBA.

9.2.3 DESIGN ANALYSIS

9.2.3.1 Margins of Safety

Each of the two sets of shield cooling coils is capable of removing 180,000 Btu/h. The heat exchanger is capable of removing 200,000 Btu/h of heat. However, the maximum heat load on the system is only 120,000 Btu/h. Therefore, there is an appreciable capacity margin in the Shield Cooling System.

Each pump is capable of handling 100% of the required cooling water flow for removing 180,000 Btu/h.

9.3 COMPONENT COOLING SYSTEM

9.3.1 DESIGN BASIS

The Component Cooling Water System, Figure 9-7, is designed to cool components carrying radioactive and potentially radioactive fluids. It provides a monitored intermediate barrier between these fluids and the Service Water System which transfers the heat to the lake. Thus, the probability of leakage of contaminated fluid into the lake is greatly reduced.

System components are rated for the maximum heat removal requirements that occur during normal, shutdown or accident operation as applicable. The parts of the system located inside containment are isolated in the event of a containment high-pressure signal (CHP). The component cooling water to the evaporators and spent fuel cooling system are isolated on SIAS. The system is designed to CP Co Design Class 1 requirements except for some non-safety related portions of the system.

9.3.2 SYSTEM DESCRIPTION AND OPERATION

9.3.2.1 System Description

The system is a closed loop consisting of three motor-driven circulating pumps, two heat exchangers, a surge tank, associated valves, piping, instrumentation and controls. The Component Cooling System is shown on Figure 9-7. The system is continuously monitored by a process monitor which detects radioactivity which may have leaked into the system from the fluids being cooled.

The component cooling pump motors are connected to two separate 2,400 volt buses, with one pump on one bus and the remaining two on the other. The pumps can be started and stopped from the main control room and also locally at the switchgear.

System volume expansion and contraction due to start-up, shutdown and changes in load are accommodated by an elevated surge tank which also maintains a constant static head of approximately 28 psi on the pump suctions. The system can be vented to the auxiliary building through a diaphragm-operated three-way valve on the surge tank. The auxiliary building in turn vents to the outside atmosphere through the Plant ventilation exhaust stack. The other port on the three-way valve is connected to the vent gas collection header and is automatically transferred in the event the Component Cooling System contains radioactive gases due to leakage from radioactive systems being cooled. A relief valve discharging to the liquid radwaste system is provided on the surge tank to protect from overpressure.

The Component Cooling Water System uses demineralized water to which an inhibitor is added for corrosion control. Makeup to the system is automatically supplied from the primary system makeup storage tank.

Heat is transferred from the system to Plant service water by means of two component cooling heat exchangers. Cooling requirements are shown on Table 9-4. Service water from the critical service water-header is provided to the tube side of the heat exchangers and the rejected heat from the system is discharged by service water into the cooling tower makeup basin.

Four main supply lines are provided to the various areas of the Plant as follows:

1. To Shutdown Cooling Heat Exchangers

2. To Engineered Safeguards Pumps

3. To Spent Fuel Pool Heat Exchangers and Radwaste Equipment

4. To Services Inside the Containment

Supply valves in these lines are operable from the main control room and all, except the containment isolation valves and the fuel pool supply line valve, are operable from the Engineered Safeguards Auxiliary Panel.

Two full-capacity valves installed in parallel are provided in the line supplying component cooling water to the shutdown heat exchangers.

9.3.2.2 Component Description

Design ratings and construction features of system components are given in Table 9-5.

Material for components, connecting piping and valves in contact with component cooling water is carbon steel, cast iron or bronze.

9.3.2.3 System Operation

Flow requirements for various operational modes are shown in Table 9-6.

1. Normal Operation

   During normal operation, one or two of the three component cooling pumps and the two component cooling heat exchangers will be in service. The pump(s) runs continuously with the other pump(s) in "Standby." The number of pumps running is determined by the discharge header pressure. The auto-start feature is automatically reset on bus undervoltage to prevent cycling the pump breaker onto a dead bus.

Both component cooling heat exchangers are required to be in service during all plant operating modes above cold shutdown because both heat exchangers are required to remove Chapter 14 heat loads. The shell side (CCW) of the heat exchangers could be damaged by excessive flow rates if only one heat exchanger is in service. Consequently, both shell sides must remain in operation to maintain the flowrate within acceptable levels.

The temperature of the component cooling water at the heat exchanger discharge is controlled between 72 °F and 90 °F by regulation of the service water flow. Gross adjustment required by seasonal temperature variations in the service water temperature is achieved by adjustment of hand indicating controllers (HICs), which position the heat exchanger service water outlet butterfly valves. Short-term fluctuations in CCW temperature are addressed by automatic temperature control of the rotary valves that bypass the butterfly valves. High/low component cooling temperature is annunciated in the control room. The CCW and service water discharge temperature from each component cooling heat exchanger is indicated in the control room.

Makeup to the Component Cooling System is pumped to the surge tank from the primary system makeup storage tank through an automatic on-off diaphragm-operated valve which is actuated by a level switch on the surge tank. Tank low level is annunciated in the control room. Chemicals for corrosion control are added to the component cooling water chemical addition tank. By recirculation of cooling water through a recirculating header connecting the discharge header to the chemical addition tank, the chemical solution flows from the tank into the pump suctions where it mixes with the component cooling water and is gradually distributed throughout the Component Cooling System.

A radiation monitor in the pump discharge header detects radioactive inleakage into the CCW system from components being cooled. High activity is annunciated in the main control room. If the radioactivity level in the system reaches a preset level above normal background as detected by the radiation monitor, the three-way valve on the surge tank, if open to room atmosphere, is automatically closed to room atmosphere and opened to the vent gas collection header which is a portion of the gaseous radwaste treatment system.

2. Shutdown Operation

During shutdown cooling, two component cooling pumps and both component cooling heat exchangers cool the primary coolant from 300°F to cold shutdown. In this case, the remaining pump will act as a spare and is manually started from the control room.

Component cooling water is supplied to the shutdown cooling heat exchangers by remote-manual opening of the piston-operated valves in the supply header from the main control room. At the start of the shutdown cooling operation, the component cooling water heat exchanger outlet temperature is at a maximum temperature of 90°F.

3. Emergency Operations

On initiation of the Safety Injection Signal (SIS), the supply of component cooling water to the Spent Fuel Cooling System and to the radwaste evaporators will be cut off by automatic closure of supply and/or return line valves. This assures additional cooling capability by the system for the safety injection and containment spray water when it is recirculated through the shutdown heat exchangers, and for cooling the glands of the safety injection, charging and containment spray pumps. The valves in the gland cooling water supply and return headers for the ESS pumps that are not electrically locked open do receive an SIS signal, however, they are normally in their SIS position. Therefore, no valve repositioning is required to provide CCW to the ESS pumps (Reference 26).

If offsite power to the CCW pumps is available during an SIS, all three pumps will be started. If offsite power is not available during an SIS, the component cooling pumps are momentarily shed from the power supply buses. After the emergency diesel generators have energized the buses, two of the pumps are automatically started by the DBA sequencers. The third pump, though not required per accident analyses, is sequenced to standby and will only start on CCW system low pressure. The system valve lineup for accident conditions is such that one pump is capable of providing required CCW flow to the two CCW heat exchangers at a higher pressure than the low pressure standby pump start setpoint.

If offsite power to the CCW pumps is lost and SIS is not present, then the pumps are shed from their respective bus. After the emergency diesel generators have energized the buses, two of the pumps are automatically started by the normal shutdown (NSD) sequencers. The third pump is sequenced later but only starts if a low pump discharge pressure is present, indicating that the other pumps have not started.

Upon receipt of an SIS, the valves in the component cooling water-supply lines to the shutdown cooling heat exchangers open. Upon receipt of a low-level signal from the SIRW tank, the valves in the component cooling heat exchanger service water high capacity outlets and component cooling water inlets open to ensure maximum cooling water supply during the containment spray and safety injection recirculation mode. Additionally, the CCW heat exchanger SW temperature control valves close. Under this condition, neither the service water nor the component cooling water flows are modulated.

The control valve in the supply line to the Spent Fuel Cooling System can be opened and closed remotely from the control room at the discretion of the operator in order to prevent overheating of the spent fuel pool.

The gland cooling water for the safety injection and containment spray pumps is backed up by service water from the critical Service Water System (see Subsection 9.1.2) in case of failure of the component cooling water supply. Low cooling water flow in the supply header to each engineered safeguards equipment room is annunciated in the control room. Changeover from one supply to the other is performed by manual operation of the Component Cooling Water Supply and Return Valves. The air supply for the Service Water Control Valves is then unisolated and one of the two Service Water Supply Valves along with the Return Valve are opened. The Service Water and Component Cooling Water Control Valves can be operated from the main Control Room or from the local Engineered Safeguards Auxiliary Panel. The air supply to the Service Water Control Valves is normally valved out of service to ensure a spurious operation of one of the Service Water Valves does not result in a loss of Component Cooling Water inventory.

The CCW supply and return header control valves for containment are designed to fail in the "Open" position in the event that air or control power is lost to the valves. This failure mode precludes the undesirable loss of component cooling water to the primary coolant pumps, control rod drive mechanisms, letdown heat exchanger or shield cooling coils during normal Plant operations. In the event of an accident which results in a containment high pressure signal, the CCW supply and return header control valves for containment will close. If instrument air is lost during the accident, the CCW return header control valves for containment are provided with accumulators sized to place and maintain the valves in a "Closed" position.

A review was performed to assess the vulnerability of CCW piping within containment to failure caused by a high-energy line break (HELB). Failure of this piping, coupled with the CCW supply valve to containment (CV-0910) failing open due to a loss of air, could cause a complete loss of CCW inventory. The review concluded that this CCW piping within containment is not vulnerable to failure caused by a HELB (References 7, 34 and 35).

During a LOCA, the temperature of component cooling water exiting the shutdown cooling heat exchanger may approach 190°F, thereby exceeding the CCW system design temperature of 140°F. Evaluation of this condition concluded that CCW system components would not be adversely affected by shutdown cooling heat exchanger outlet temperature of 190°F or less (Reference 28).

The LOCA response analysis provided a temperature higher than the 140°F system design temperature downstream of the CCW heat exchangers. Reference 63 was completed to revise the design temperature of the portion of the system downstream of the CCW heat exchangers to the shutdown cooling heat exchangers to 165°F

9.3.3 DESIGN ANALYSIS

9.3.3.1 Margins of Safety

1. Any one of three pumps is capable of supplying component cooling requirements during normal Plant operation. During shutdown, one pump can furnish at least 50% of the maximum shutdown cooling water requirements. For post-DBA operation, one pump can furnish 100% of the required capability for cooling the containment spray and safety injection recirculation water. For the Left Channel DBA condition, containment cooling is achieved using two containment spray pumps. For the right channel DBA, containment cooling is achieved using one spray pump and containment air coolers (VHX-1, 2 & 3), which do not require CCW.

2. Pump motor power is normally supplied from offsite sources with backup supplied from the emergency diesel generators.

3. Two 50% capacity heat exchangers (based on maximum duty during shutdown cooling) are provided; each heat exchanger alone is capable of primary system cooldown at a reduced rate. Under Chapter 14 accident conditions, each heat exchanger is capable of handling at least 50% of the heat duty required, but neither is capable of handling 100% of the heat duty by itself. The shell side of both heat exchangers must be operable at all times in order to prevent excessive flow conditions which could damage the heat exchangers. Both heat exchangers are required to be operable when $T_{AVE} \geq 325°F$ because one heat exchanger is assigned to each train, and both trains are required to be operable per Technical Specification LCO 3.7.7.

4. Two full-capacity valves installed in parallel in the component cooling water-supply header to the shutdown heat exchangers ensure a reliable supply of cooling water for shutdown and for the post-DBA recirculation mode of operation.

9.3.3.2 Provisions for Testing and Inspection

Each pump was shop-tested in accordance with requirements of the Standards of Hydraulic Institute. The heat exchangers were each hydrostatically tested in accordance with the requirements of the ASME B&PV Code, Section III, Class C, 1965. Valve bodies were hydrotested in accordance with requirements of AWWA-C504.

Components of the Component Cooling System outside the containment are accessible for periodic inspection during Plant operation. Components inside the containment are normally accessible during Plant shutdown only.

Provisions are provided as necessary to facilitate ASME OM Code required tests as well as operability and performance tests.

9.4 SPENT FUEL POOL COOLING SYSTEM

9.4.1 DESIGN BASIS

The spent fuel pool cooling system removes decay heat from spent fuel stored in the spent fuel pool. The system was originally designed to remove the decay heat from one-third of the total core fuel elements.

The spent fuel pool cooling system is required to maintain the fuel pool water temperature less than 150°F with a minimum of one spent fuel pool cooling pump operating. The maximum spent fuel pool heat load resulting from off-loaded spent fuel shall be less than 28.64×10^6 Btu/hr regardless of whether the heat load is from a one-third core off-load or a full core off-load. A heat load less than 28.64×10^6 Btu/hr ensures that the spent fuel pool water temperature limit of 150°F is maintained with one pump in operation. Heat is removed from the spent fuel pool by the spent fuel pool heat exchanger with component cooling water providing the cooling medium.

The replacement spent fuel storage racks installed in 2013 (refer to Section 9.11) have a maximum potential heat load of 28.9×10^6 Btu/hr (Reference 9.78). The administratively controlled limit, per this section, remains 28.64×10^6 Btu/hr.

The fuel handling area, including the spent fuel pool, is a CPCo Design Class 1 structure and the spent fuel pool cooling system is a CPCo Design Class 1 system and is tornado protected, except as noted.

9.4.2 SYSTEM DESCRIPTION AND OPERATION

9.4.2.1 System Description

The fuel pool cooling system is a closed loop system consisting of two pumps, a heat exchange unit consisting of two heat exchangers in series, a bypass filter, a bypass demineralizer, a booster pump, piping, valves and instrumentation. The bypass filter element was removed from the housing due to ALARA concerns; refer to Section 11.6.4.3 for details. The spent fuel pool cooling system is shown on Figure 9-8.

Materials used in the spent fuel pool cooling system are suitable for use with borated water (2% by wt boric acid). Fuel pool makeup water is supplied from the Primary System Makeup Storage Tank (T-90), the Recycled Boric Acid Storage Tank (T-96), and the Safety Injection & Refueling Water Tank (T-58). In the event of a considerable loss of pool water, the fire system can be used to replenish the pool water content.

The clarity and purity of the water in the spent fuel pool are maintained by passing a portion of the flow through the bypass filter and/or demineralizer. Skimmers are provided in the spent fuel pool to remove accumulated dust from the pool. The skimmers have experienced leakage and are not normally used.

Connections are provided for a temporary tie-in to the Shutdown Cooling System to provide a backup capability for the fuel pool heat exchangers.

The spent fuel pool cooling system is connected by valved piping to the reactor refueling cavity to cool the refueling cavity water during spent fuel transfer.

9.4.2.2 Component Description

Design ratings and construction of components are shown in Table 9-7.

9.4.2.3 System Operation

1. Normal Operation

   During normal operations, one of the two pumps is operated. The pumps are started and stopped from the main control room. A pressure switch on the discharge header annunciates low header pressure in the main control room. A manually controlled booster pump provides flow through the fuel pool demineralizer. The flow is regulated by manual valve adjustment.

2. Shutdown Operation

   During cold shutdown refueling condition, the reactor refueling cavity is filled with borated water from the SIRW tank. The reactor refueling cavity water can be cooled by the fuel pool heat exchanger and purified as needed by the filter and/or the demineralizer. The fuel pool cooling pumps empty the refueling cavity water into the SIRW tank after refueling is completed. The fuel tilting mechanism pits can be filled and emptied through the fuel pool cooling system piping interconnections and fuel pool pumps.

3. Post-Accident Operation

   In the event of a DBA, if auxiliary power is available, a pump will continue to run if it was running before the accident. If no auxiliary power is available, the pump is shed from the power supply bus. After the emergency diesel generators are running and the engineered safeguards equipment is in operation, the fuel pool cooling system can be operated intermittently from the main control room to remove decay heat generated by the spent fuel elements and thus prevent overheating of the spent fuel pool.

9.4.3 DESIGN ANALYSIS

9.4.3.1 Margins of Safety

The analysis of the spent fuel pool cooling system (Reference 73) determined that, assuming a heat load of 28.64×10^6 Btu/hr, a heat transfer area of 3163.6 ft^2 would still maintain adequate heat removal capacity. This corresponds to 140 tubes per heat exchanger plugged. The following chart shows the offload scenario (hypothetical) that bounds normal one-third core or full core offloads:

Parameter	Value
Heat Load, Btu/h	28.64×10^6
Spent Fuel Pool Pump Flow (one pump), gpm	1530
Component Cooling Water Flow, gpm	1800
Spent Fuel Pool Inlet Temperature, °F	149.4
Component Cooling Water Inlet Temperature, °F	90
Heat Transfer Area, ft^2	3163.6
Heat Transfer Coefficient, Btu/hr ft °F	300

NOTE: Failure of the outlet piping system would result in draining of the fuel pool to the outlet level which still maintains an adequate level of water in the pool for shielding and cooling requirements. Such a failure could occur as a result of a wind or tornado generated missile striking a portion of the spent fuel pool cooling pump P-51B discharge piping that extends above the spent fuel pool building floor.

Failure of the inlet piping would result in no loss of water from the fuel pool as there is no downcomer by which a siphon could be started.

9.4.3.2 Provisions for Testing

When the cooling system is inoperative, starting and stopping of both pumps can be tested from the main control room by manually operating the switches.

9.5 COMPRESSED AIR SYSTEMS

The Compressed Air Systems consist of the Instrument Air System, the High Pressure Air System, various backup systems, and the Feedwater Purity Air System.

9.5.1 INSTRUMENT AIR SYSTEM

9.5.1.1 Design Basis

The Instrument Air System is a non-safety related system that is required for normal plant operations. The system is designed to provide a reliable supply of dry, oil-free air for instruments and controls, and for service air requirements. The design of the system is based on an estimated instrument air consumption rate of 80 scfm for the Nuclear Steam Supply System and 115 scfm for the remainder of the Plant.

9.5.1.2 System Description

Three 288 scfm (C-2A, C-2B and C-2C) oil-free air cooled compressors are provided, each with an in-line air receiver tank. While the compressors are air-cooled, each has an in-line, aftercooler to provide a cooling function to remove moisture from discharge air. The C-2A and C-2C supplemental aftercoolers are served by critical service water. The supplemental aftercooler for C-2B is serviced by non-critical service water. The air receivers are connected to a common discharge air header. The common air header branches into two separate air headers, one to the instrument air dryer and filter assembly, and one to the Service Air System. The system is shown on Figure 9-9.

The instrument and service air headers are divided into branch lines supplying the Turbine Building, the Containment Building, the Intake Structure, and the Auxiliary Building.

A fail-open, air-operated, isolation valve in series with a check valve is located in the instrument air line outside the Containment Building. The isolation valve is designed to fail-open to provide a supply of instrument air to controls inside the Containment Building while instrument air is available. Closure of the isolation valve can be achieved via nitrogen backup if instrument air is not available.

9.5.1.3 Component Description

Design ratings and construction of components are shown on Table 9-8.

9.5.1.4 System Operation

a. Normal Operation

A continuous supply of a minimum of 80 psig instrument air is provided to hold power-operated valve actuators in the positions required for operating conditions and to provide air for modulating control valves. One of the two equipment lineups described below will normally be in service.

1. The control switch for a compressor (C-2A, C-2B or C-2C) will be placed in the “HAND” or operating position and supplying Plant loads with one of the remaining two compressors (C-2A, C-2B or C-2C) in the “AUTO” or standby position. The third compressor can be placed in either the “AUTO” position or the “OFF” position as desired by Operations. One Feedwater Purity Air Compressor (C-903A or C-903B) will be operating at a constant speed with controls that load and unload in response to variations in the pressure in the Feedwater Purity Air Receiver Tanks. The other Feedwater Purity Air Compressor is in auto start on bias pressure differential. Feedwater Purity is not cross-tied to the Plant Air System.

2. One Feedwater Purity Air Compressors (C-903A or C-903B) will be operating at a constant speed with controls that load and unload in response to pressure variations in Feedwater Purity Air Receiver Tanks (T-928A or T-928B). The Feedwater Purity Oil Separator (F-985) and Air Dryer (M-993) are in service with the other Feedwater Purity Air Compressor in auto start on bias pressure differential. Feedwater Purity is cross-tied to the Plant Air System supplying both Feedwater Purity and Plant Air Systems.

The standby compressor(s) (C-2A, C-2C or C-2B) start when pressure in the air receiver discharge header drops to 92 psig. Each of the air compressors can be started, set on standby, or tripped by a separate control switch in the Main Control Room.

The standby compressor (C-903A or C-903B) start when predetermined bias pressure is reached between the two Feedwater Purity Air Compressors. The Feedwater Purity Air Compressors C-903A and C-903B controls switches are located in the Feedwater Purity Building, however, controls for allowing Feedwater Purity Air to be cross-tied to the Plant air system is located in the control room.

The instrument air header downstream of the filters has a pressure switch which initiates the closing of a shutoff valve on the service air header in the event that the instrument air pressure drops to 85 psig. In addition, low pressure is alarmed in the control room.

b. Shutdown Operation

If offsite power is available, the Instrument Air System remains capable of performing its design function whether the plant is operating or shutdown. In case of offsite power failure, compressors motors are shed from their normal bus and compressors C-2A, C-2B and C-2C can be manually restarted on emergency power from the diesel generators.

c. Post-DBA Operation

In the event of a Design Basis Accident (DBA) with loss of offsite power, the compressor motors are shed from the normal ac bus. Subsequently, the emergency diesel generators are started and the compressors C-2A, C-2B and C-2C can be manually started to restore the air supply when diesel loading permits. If offsite power is available, the system operation is the same as during normal plant operation.

9.5.1.5 Design Analysis

a. Design Margin

The three air compressors in the Instrument Air System are each rated to deliver 288 scfm. The total system design requirement is 195 scfm.

b. Provisions for Testing and Inspection

Each compressor can be tested to ensure operability with manual "on-off" switches located in the Main Control Room (one switch for each compressor).

c. Failure Analysis

Instrument air is primarily used for motive power for valve actuation and is not used in any reactor indication, control, or protective circuit. The design of the system and redundancy of equipment and power supplies ensure that total loss of instrument air is highly improbable; however, attention has been given to the overall Plant design to ensure that valve failures upon loss of air are consistent with the capability to maintain the Plant in a safe condition and to mitigate the consequences of any simultaneous incident or accident.

The safety positions and position on a loss of air supply for significant safety related or important to safety air-operated valves are listed in Table 9-9. No failure of valves due to degraded instrument air precludes maintaining the Plant in a safe condition provided the backup systems are available.

9.5.2 HIGH PRESSURE AIR SYSTEM

9.5.2.1 Design Basis

The safety related portion of the High Pressure Air System in the East and West Safeguards Rooms extends from the air receivers to the control valves serviced and is isolated from the non-safety related portion by check valves. The air receivers for this portion of the system are sized to allow each RAS (Recirculation Actuation Signal) valve operator, normally supplied by air from this system, to be cycled (open to close to open OR close to open to close) with the compressor inoperable and the initial pressure (260 psi) below the low-pressure alarm set point (300 psi) (Reference 57). This assures operability of those cylinder-operated safeguards valves necessary for large break LOCA conditions.

The portion of the High Pressure Air System in the Turbine Building is not a safety related system. It provides air for main feedwater stop valves CV-0742 and CV-0744, and for condenser fast makeup control valve CV-0733. Also, it can provide a backup for the safety related air receivers in the East and West Safeguard's High Pressure Air Systems.

9.5.2.2 System Description

The High Pressure Air System, shown on Figure 9-10, consists of three high-pressure, oil lubricated air compressors, each with its own air dryer and air receiver. The high pressure air compressors in the East and West Engineered Safeguards Rooms supply air to the safety related receivers which provide high pressure control air for valves (CV-3018, CV-3027, CV-3029, CV-3030, CV-3031, CV-3037, CV-3055, CV-3056, CV-3057, CV-3059) located in the two engineered safeguards rooms. The East and West Safeguards Rooms systems are not permitted to be cross connected when engineered safeguards equipment is required to be operable. The Turbine Building system can supply either the East or the West Safeguards systems during any plant mode. Moisture is removed from the high-pressure air by air dryers that are in series with the compressors' air-cooled aftercooler. Any remaining moisture is removed by periodic blowdown of the air receivers and the low point drains.

9.5.2.3 Component Description

Design ratings and construction of components are shown on Table 9-8.

9.5.2.4 System Operation

a. Normal Operation

Each high-pressure air compressor operates automatically to maintain a pressure between 310 and 325 psig in its individual receiver tank.

b. Shutdown Operation

When offsite power is available, the system operation is the same as the normal operation. In the case of offsite power failure, the compressors can be restarted manually on emergency power from the emergency diesel generators.

c. Post-DBA Operation

In the event of a DBA with loss of offsite power, the compressor motors are shed from the normal ac bus. Assuming the air compressors are not manually restarted from the emergency diesel generators and the DBA is a large break LOCA, sufficient air is available in the receiver tanks to meet system requirements. If the DBA is a small break LOCA, then manual action may be required to restore an air supply in order to meet system requirements. Whether offsite power is available or power from the emergency diesel generators is used, the system operation is the same as the normal operation.

9.5.2.5 Design Analysis

a. Margins of Safety

The High Pressure Air System air receiver tanks have sufficient volume to achieve RAS assuming the loss of the air compressors following a large break LOCA. The minimum operating pressure setting is established at a value well above the minimum required operating pressure of the RAS valves.

b. Provisions for Testing and Inspection

Testing is performed to demonstrate that the High Pressure Air System is capable of performing its design functions.

c. Failure Analysis

In the unlikely event of a large break LOCA occurring simultaneously with loss of high pressure air, there will be sufficient stored air capacity available in the receivers to position the safeguards valves after a RAS (Reference 57). In the event of a small break LOCA, manual action may be required to restore an air supply in order to position the safeguards valves after a RAS. Also, backup stations are available to supply nitrogen to valves CV-3027 and CV-3056 (safeguards pumps recirculation to SIRW tank) and air to CV-3018 (HPSI header cross-tie valve).

9.5.3 BACKUP SYSTEMS

The backup systems consist of bottled nitrogen stations, a bottled air station, bulk nitrogen, local accumulators, and manual valve actuators.

9.5.3.1 <u>Design Basis</u>

There are six nitrogen backup stations designed to provide compressed nitrogen for valve operation and control of selected valves should the pressure for the normal air supply drop below a specified value. The stations are connected to the air lines via check valves so that operation of the systems is passive, depending only upon the normal air supply line pressure.

The nitrogen backup stations are treated as being safety related, except for the capability of some stations to withstand certain external events such as earthquake, seiche, and tornado since they are located in non-protected structures. The stations allow operation of certain valves for a specific period of time and are credited in events such as accident mitigation, a fire or a station blackout.

The bottled air backup station is designed to provide motive force for operation and control of valve CV-3018 (HPSI header cross-tie) should the pressure from the normal air supply drop below a specified value following loss of a compressor.

A bulk nitrogen backup system provides backup for the instrument air supply to the Main Steam System's Atmospheric Dump Valves (ADVs) when instrument air pressure drops below 85 psig. Bulk nitrogen is utilized as the source of nitrogen rather than a bottled system due to the large volume of nitrogen needed to provide for the four hour coping duration necessary to meet Station Blackout requirements. Use of bulk nitrogen allows the ADVs to exceed the Station Blackout coping duration requirements of 10CFR 50.63 as recommended in Reg Guide 1.155. See Section 8.1.5 for an additional description of Palisades' response to Station Blackout requirements. The pressure regulator on the bulk nitrogen is sized to fully open all four ADVs simultaneously. There is also a solenoid valve which ensures that, upon a loss of instrument air and nitrogen backup, installed air accumulators are capable of rapidly opening the ADVs. Nitrogen backup to the ADVs is not considered safety related per Reg Guide 1.155 and is not required for the operability of the ADVs. However, the nitrogen backup is required to support safe and stable conditions per National Fire Protection Association (NFPA) 805.

An additional backup station, Station 9, provides backup nitrogen to the ADVs for beyond-design-basis events (Reference 77)."

Some valves are equipped with manual valve actuators to permit valve actuation following a loss of motive power.

9.5.3.2 System Description

The nitrogen and air backup stations are shown on Figure 9-9, Sheet 2.

9.5.3.3 Component Description

Design ratings of nitrogen backup bottles are shown on Table 9-8.

9.5.3.4 System Operation

The nitrogen backup stations are passive systems and are configured to provide compressed nitrogen to certain valves in the Plant if the instrument air pressure drops below a pre-set value, irrespective of Plant operating mode.

The bottled air backup station is available in any Plant mode. However, it needs to be manually connected in order to supply pressurized air to CV-3018.

9.5.3.5 Design Analysis

a. Margins of Safety

The backup systems support the ability of other systems to meet design requirements by providing the capability to operate and control certain valves when normal air supply pressure drops below a pre-set value.

b. Provisions for Testing and Inspection

Tests are periodically performed to verify that the nitrogen backup systems are capable of operating their associated valves. The scope of the testing includes verifying the output of the nitrogen bottles and measuring leakage from the stations to assure that leak rate acceptance criteria are met.

9.5.4 FEEDWATER PURITY AIR SYSTEM

9.5.4.1 Design Basis

The Feedwater Purity Air System is not a safety related system. When manually aligned, the system is capable of supplying air to the Instrument and Service Air System.

9.5.4.2 System Description

The Feedwater Purity Air System is supplied by two air compressors, each with an integral intercooler and a separate after-cooler and receiver. This system is independent of the other compressed air systems at the Plant but can be tied into the Instrument and Service Air header. When tied to the Instrument and Service Air Systems header, Feedwater Purity air is piped directly to the service air header but the instrument air supply is routed through a dryer. The compressors are cooled by water supplied from the non-critical service water header. Clean, dry air can be provided from the M-993 Air Dryer via the FWP air system cross-connect.

9.5.4.3 Component Description

Design ratings and construction of components are shown on Table 9-8.

9.5.4.4 System Operation

The air compressors operate automatically to maintain approximately 110 psig in the air receiver tanks. If necessary, the diesel generators can be manually aligned to provide power to the Feedwater Purity air compressors.

9.5.5 RADWASTE AREA COMPRESSOR

The Radwaste Area Compressor C-15 is not safety related. C-15 is capable of supplying 220 scfm of air at 125 psig pressure. It was designed to supply air to the Radwaste Volume Reduction System. If necessary, C-15 can be aligned to provide air to the service air system under off-normal conditions. This can also be used for breathing air by the workers in the containment.

9.6 FIRE PROTECTION

9.6.1 DESIGN BASIS

Fire protection uses a defense-in-depth concept to provide a high degree of safety. The plant is designed to prevent fires, detect and suppress fires quickly, limiting their damage, and preventing safe shutdown functions and systems from being interrupted.

Fire Protection systems are designed in accordance with the guidance of the National Fire Protection Association, the American Insurance Association, NEPIA (now American Nuclear Insurers), and the applicable codes and regulations of the State of Michigan.

The primary objective of the fire protection program is to minimize both the probability and consequences of postulated fires. Fires are expected to occur, therefore, means are provided to detect and suppress fires with particular emphasis on providing passive and active fire protection of appropriate capability and adequate capacity for the systems necessary to achieve safe and stable conditions with or without offsite power. For safe and stable systems, fire protection ensures that a fire would not cause the loss of function of such systems, even though loss of redundancy within a system may occur as a result of the fire.

In plant areas where the potential for fire damage may jeopardize safe and stable conditions, the primary means of fire protection consists of fire barriers and fixed automatic fire detection and suppression systems. However, total reliance is not placed on a single fire suppression system. Appropriate backup fire suppression capability is provided throughout the plant to limit the extent of fire damage. Portable equipment consisting of fire hoses, nozzles, portable extinguishers, personnel protective equipment, and air breathing equipment is provided for use by the trained fire brigade. Access to the manual application of fire extinguishing agents to combustibles is provided.

The fire suppression water system may also provide backup water supply to the auxiliary feedwater pump suction, critical service water, and the spent fuel pool fill. The fire pumps are housed in the Class 1 portion of the screen house. The backup supply header to the auxiliary feedwater pumps is buried underground for protection against tornadoes. A cross connection connects the fire pump discharge header to each of the critical service water header lines. Both of the above cross connections are protected from tornadoes. A header terminating in a blind flange is provided in the spent fuel pool heat exchanger room for emergency filling of the spent fuel pool. The fire pump test header also has a direct cross-tie to the screen wash header to provide an alternate source of water to clean the traveling screens.

The diesel engine driven fire pumps and the piping connecting the fire suppression water system to the auxiliary feedwater system are designed to Consumers Design Class 2 requirements (see Subsection 5.2.1.2). The remainder of the system is designed to Consumers Design Class 3 requirements. Appropriate valving is provided to separate the system if required.

A fire brigade of at least five members is maintained on site at all times, except for unexpected absences when the composition may be less than the minimum for a period of time not to exceed two hours. The fire brigade will not include three members of the minimum shift crew necessary for establishing safe and stable conditions or any personnel required for other essential functions during a fire emergency. Personal protective clothing and air breathing apparatus are provided for the brigade. Fire brigade qualifications and training are described in plant procedures. The fire brigade training program, as practical, meets or exceeds the requirements of NFPA 600-2000.

9.6.2 SYSTEM DESCRIPTION AND OPERATION

9.6.2.1 System Description

Building structures have been designed and arranged to prevent the spread of fire and ensure integrity of redundant safe and stable systems and areas. A complete description of fire areas, barriers, and means of fire protection is detailed in the Fire Safety Analyses within the NFPA Fire Protection Program (Reference 43).

The fire water system is shown in Figure 9-11. Fire suppression is provided by fixed water spray systems, including sprinklers systems, deluge systems, fire hose reels and cabinets. These fire suppression provisions are found throughout the plant site. The fire hydrant piping system is designed, installed and tested in accordance with the guidance of NFPA 24-1965, Outside Protection. The pumping supply system and fire pumps are designed and installed in accordance with NFPA 20-1966, Installation of Centrifugal Fire Pumps. NFPA 20-1972 was specified for procurement of the second diesel engine driven fire pump.

Fire hoses from fire hydrants and a standpipe system will provide protection in accordance with the guidance of NFPA 14-1963, NFPA 20-1966, and NFPA 24-1965. The standpipe system is designed, installed and tested as a Class II system in accordance with the guidance of NFPA 14-1963, Installation of Standpipe and Hose Systems. Readily accessible rack or reel mounted fire hose lines with electrically safe fog-type nozzles are located throughout the Plant. All areas in the turbine building and auxiliary building which contain or expose safety related systems are within effective firefighting range of at least one hose station.

Fixed water spray systems, such as wet pipe fusible link sprinkler systems, dry pipe fusible link sprinkler systems, and fixed fog deluge spray systems are designed, installed and tested in accordance with the guidance of NFPA 13-1968, Installation of Sprinkler Systems and NFPA 15-1962, Water Spray Fixed Systems for Fire Protection. Water Flow Alarms provide fire detection and indication of individual system water flow in various areas, and is indicated on an annunciator panel in the main control room.

Fixed fog deluge systems protect the main, start-up and station auxiliary transformers. Each of these deluge systems are automatically actuated and annunciated by a general alarm in the main control room. A manual operated fixed fog deluge system protects the charcoal filters used to maintain the control room habitability.

The wet pipe and dry pipe fusible link sprinkler systems are provided in selected plant areas as identified in the Fire Safety Analyses. Actuation of any sprinkler system is annunciated by a general alarm in the main control room.

Fire detection is provided in the form of smoke and ultraviolet detectors. These detectors were located and installed in accordance with the guidance of NFPA 72E-1974, except inside containment at the electrical penetrations where detectors are placed in proximity to the areas of highest combustible loading. The fire detectors are located in selected plant areas as identified in the Fire Safety Analyses and listed in Table 9-10. Initiation of any of these detector zones alarms is on the annunciator panel located in the main control room and in Switchgear Room 1D. Water flow switches are also provided to indicate actuation of a sprinkler system.

9.6.2.2 Component Description

Water for the fire suppression system is supplied by one of three full capacity fire pumps. Each fire pump is capable of providing water to the largest system demand plus fire hose streams in the area of demand. One fire pump is electrically driven, and the other two are diesel engine driven. Any fire pump will start automatically and can be manually started from the pump control panel. The diesel engine driven fire pumps can also be manually started from the main control room.

A jockey fire pump with local controls is provided to maintain the fire suppression system full and pressurized.

Smoke detectors are provided as described in the Fire Safety Analyses and listed in Table 9-10. There is an ultraviolet fire detection system installed in the screen house. The fire detection control panel (C-132) has battery backup and along with the detectors gives alarm annunciation to the control room for a fire throughout the area. The ultraviolet detectors should eliminate nuisance alarms that could be generated by other types due to the heat from the exhaust system of the diesel driven fire pumps in the room.

Portable fire extinguishers are provided at convenient and accessible locations. The extinguishing media are pressurized water, carbon dioxide, or dry chemical as appropriate for the service requirements of the area.

Electric cable fire protection is provided by approved fire barriers and fire stops, in addition to the above fire detection and automatic sprinkler systems where needed to augment separation requirements. See Section 8.5 for details of cable separation requirements.

9.6.2.3 System Operation

The motor driven fire pump starts automatically on low fire system header pressure of 98 psig. The first diesel engine driven fire pump starts upon a pressure drop to 83 psig and then the second diesel driven fire pump starts upon a further drop in pressure to 68 psig. The diesel driven fire pumps are thus arranged to back up the motor driven fire pump in case the latter does not start. The diesel driven fire pumps start circuits also have time delays to prevent simultaneous starting of the fire pumps.

The jockey fire pump operates continuously to keep the system pressurized at or above 100 psig. Water from the jockey fire pump is recirculated back into the service water bay via a minimum flow orifice. A check valve isolates the orifice when a main fire pump operates thus conserving water to fight the fire. Should the jockey pump be removed from service for maintenance, the fire suppression water system header pressure will be maintained through operation of the motor driven fire pump or through a temporary connection to a service water booster pump which takes suction from the non-critical service water header. In the case of a failure of the jockey pump or the temporary connection, the fire suppression water system will be pressurized by automatic operation of the motor driven fire pump by tripping of one or all of the pump’s header pressure switches. Operation of the motor driven fire pump is annunciated in the control room to alert the operator of system usage.

The backup supply to the other systems is activated by locally starting a fire pump and hand opening the block valves.

Administrative procedures are used to monitor and control combustible materials when required for use in safety-related areas and throughout the Plant.

9.6.3 DESIGN ANALYSIS

The Palisades Fire Safety Analyses are based on physical evaluation of plant systems, structures, components and fire detection and suppression provisions, coupled with plant design and construction documentation. In the analyses, fire areas have been identified and evaluated with respect to the following:

- General area description
- Identification of hazards, including combustible materials and potential ignition sources
- Overview of the fire protection features and supporting analysis and exemptions
- Fire barriers defining the area
- Manual suppression provisions
- Potential for radiological release
- Results of risk-informed, performance-based evaluation
- Achievement of nuclear safety performance criteria

Fire areas are areas that are sufficiently bounded to withstand the hazards associated with the area and, as necessary, to protect important equipment within the area from a fire outside the area.

A nuclear safety capability assessment was performed to address the ability of the plant to achieve safe and stable conditions following a fire in any one of the fire areas. The nuclear safety capability assessment complies with the requirements of NFPA 805, Performance Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants.

9.6.4 FIRE PROTECTION PROGRAM

The fire protection program is based on the NRC requirements and guidelines, Nuclear Electric Insurance Limited (NEIL) Property Loss Prevention Standards and related industry standards. With regard to NRC criteria, the fire protection program meets the requirements of 10 CFR 50.48(c), which endorses, with exceptions, the National Fire Protection Association's (NFPA) 805, "Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants - 2001 Edition. Palisades has further used the guidance of NEI 04-02, "Guidance for implementing a Risk-Informed, Performance-Based Fire Protection Program under 10 CFR 50.48(c)" as endorsed by Regulatory Guide 1.205, "Risk-Informed, Performance Fire Protection for Existing Light-Water Nuclear Power Plants."

Adoption of NFPA 805, "Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants", 2001 Edition in accordance with 10 CFR 50.48(c) serves as a method of satisfying 10 CFR 50.48(a) and General Design Criterion (GDC) 3.

NFPA 805 does not supersede the requirements of GDC 3, 10 CFR 50.48(a), or 10 CFR 50.48(f). Those regulatory requirements continue to apply. However, under NFPA 805, the means by which GDC 3 or 10 CFR 50.48(a) requirements are met may be different than under 10 CFR 50.48(b). Specifically, whereas GDC 3 refers to SSCs important to safety, NFPA 805 identifies fire protection systems and features required to meet the Chapter 1 performance criteria through the methodology in Chapter 4 of NFPA 805. Also, under NFPA 805, the 10 CFR 50.48(a)(2)(iii) requirement to limit fire damage to SSCs important to safety so that the capability to safely shut down the plant is satisfied by meeting the performance criteria in Section 1.5.1 of NFPA 805.

A Safety Evaluation was issued on February 27, 2015 by the NRC, that transitioned the existing fire protection program to a risk-informed, performance-based program based on NFPA 805, in accordance with 10 CFR 50.48(c).

9.6.4.1 Design Basis Summary

9.6.4.1.1 Defense-in-Depth

The fire protection program is focused on protecting the safety of the public, the environment, and plant personnel from a plant fire and its potential effect on safe reactor operations. The fire protection program is based on the concept of defense-in-depth. Defense-in-depth shall be achieved when an adequate balance of each of the following elements is provided:

1. Preventing fires from starting,

2. Rapidly detecting fires and controlling and extinguishing promptly those fires that do occur, thereby limiting fire damage,

3. Providing an adequate level of fire protection for structures, systems, and components important to safety, so that a fire that is not promptly extinguished will not prevent essential plant safety functions from being performed.

9.6.4.1.2 NFPA 805 Performance Criteria

The design basis for the fire protection program is based on the following nuclear safety and radiological release performance criteria contained in Section 1.5 of NFPA 805:

- Nuclear Safety Performance Criteria. Fire protection features shall be capable of providing reasonable assurance that, in the event of a fire, the plant is not placed in an unrecoverable condition. To demonstrate this, the following performance criteria shall be met.

(a) Reactivity Control. Reactivity control shall be capable of inserting negative reactivity to achieve and maintain subcritical conditions. Negative reactivity inserting shall occur rapidly enough such that fuel design limits are not exceeded.

(b) Inventory and pressure Control. With fuel in the reactor vessel, head on and tensioned, inventory and pressure control shall be capable of controlling coolant level such that subcooling is maintained such that fuel clad damage as a result of a fire is prevented for a PWR.

(c) Decay Heat Removal. Decay heat removal shall be capable of removing sufficient heat from the reactor core or spent fuel such that fuel is maintained in a safe and stable condition.

(d) Vital Auxiliaries. Vital auxiliaries shall be capable of providing the necessary auxiliary support equipment and systems to assure that the systems required under (a), (b), (c), and (e) are capable of performing their required nuclear safety function.

(e) Process Monitoring. Process monitoring shall be capable of providing the necessary indication to assure the criteria addressed in (a) through (d) have been achieved and are being maintained.

- Radioactive Release Performance Criteria. Radiation release to any unrestricted area due to the direct effects of fire suppression activities (but not involving fuel damage) shall be as low as reasonably achievable and shall not exceed applicable 10 CFR, Part 20, limits.

Chapter 2 of NFPA 805 establishes the process for demonstrating compliance with NFPA 805.

Chapter 3 of NFPA 805 contains the fundamental elements of the fire protection program and specifies the minimum design requirements for fire protection systems and features.

Chapter 4 of NFPA 805 establishes the methodology to determine the fire protection systems and features required to achieve the nuclear safety performance criteria outlined above. The methodology shall be permitted to be either deterministic or performance-based. Deterministic requirements shall be "deemed to satisfy" the performance criteria, defense-in-depth, and safety margin and require no further engineering analysis. Once a determination has been made that a fire protection system or feature is required to achieve the nuclear safety performance criteria of Section 1.5, its design and qualification shall meet the applicable requirement of Chapter 3.

9.6.4.1.3 Codes of Record

The codes, standards and guidelines used for the design and installation of plant fire protection systems are as follows (Reference 76):

1. NFPA 10-1967, Standard for Portable Fire Extinguishers

2. NFPA 13-1968, Standard for the Installation of Sprinkler Systems
3. NFPA 14-1963, Standard for the Installation of Standpipe and Hose Systems
4. NFPA 15-1962, Standard for Water Spray Fixed Systems for Fire Protection
5. NFPA 20-1966(1972), Standard for the Installation of Stationary Pumps for Fire Protection
6. NFPA 24-1965, Standard for the Installation of Private Fire Service Mains and their Appurtenances.
7. NFPA 72D-1967(1975)(1979), Standard for the Installation, Maintenance and Use of Proprietary Protective Signaling Systems
8. NFPA 72E-1974(1984), Standard on Automatic Fire Detectors
9. NFPA 80-1967, Standard for Fire Doors and Fire Windows
10. NFPA 600-2000, Standard on Industrial Fire Brigades

9.6.4.2 System Description

9.6.4.2.1 Required Systems

Nuclear Safety Capability Systems, Equipment, and Cables

Section 2.4.2 of NFPA 805 defines the methodology for performing the nuclear safety capability assessment. The results of the nuclear safety capability assessment are discussed in the NFPA 805 Fire Protection Program (Reference 43).

Fire Protection Systems and Features

Chapter 3 of NFPA 805 contains the fundamental elements of the fire protection program and specifies the minimum design requirements for fire protection systems and features. Compliance with Chapter 3 is documented in the, NFPA 805 Fire Protection Program (Reference 43).

Chapter 4 of NFPA 805 establishes the methodology and criteria to determine the fire protection systems and features required to achieve the nuclear safety performance criteria of Section 1.5 of NFPA 805. These fire protection systems and features shall meet the applicable requirements of NFPA 805 Chapter 3. These fire protection systems and features are documented in the NFPA 805 Fire Protection Program (Reference 43).

Radioactive Release

Structures, systems, and components relied upon to meet the radioactive release criteria are discussed in the, NFPA 805 Fire Protection Program (Reference 43).

9.6.4.2.2 Definition of "Power Block" Structures

Where used in NFPA 805 Chapter 3, the terms "Power Block" and "Plant" refer to structures that have equipment required for nuclear plant operations. For the purposes of establishing the structures included in the fire protection program in accordance with 10 CFR 50.48(c) and NFPA 805, the plant structures listed in Table 9-21 are considered to be part of the 'power block'.

9.6.4.3 Safety Evaluation

The NFPA 805 Fire Protection Program (Reference 43) documents the achievement of the nuclear safety and radioactive release performance criteria of NFPA 805 as required by 10 CFR 50.48(c). This document fulfills the requirements of Section 2.7.1.2, "Fire Protection program Design Basis Document," of NFPA 805. The document contains the following:

- Identification of significant fire hazards in the fire area. This is based on NFPA 805 approach to analyze the plant from an ignition source and fuel package perspective.
- Summary of the Nuclear Safety Capability Assessment (at power and non-power) compliance strategies.
- Summary of the Non-Power Operations Modes compliance strategies.
- Summary of the Radioactive Release compliance strategies.
- Summary of the Fire Probabilistic Risk Assessments.

9.6.4.4 Fire Protection Program Documentation, Configuration Control and Quality Assurance

In accordance with Chapter 3 of NFPA 805, a fire protection plan documented in FPIP-1, "Fire Protection Plan, Organization and Responsibilities," defines the management policy and program direction and defines the responsibilities of those individuals responsible for the plan's implementation. This procedure:

- Designates the senior management position with immediate authority and responsibility for the fire protection program.
- Designates a position responsible for the daily administration and coordination of the fire protection program and its implementation.
- Defines the fire protection interfaces with other organizations and assigns responsibilities for the coordination of activities. In addition, FPIP-1 identifies the various plant positions having the authority for implementing the various areas of the fire protection program.
- Identifies the appropriate authority having jurisdiction for the various areas of the fire protection program.
- Identifies the procedures established for the implementation of the fire protection program, including the post-transition change process and the fire protection monitoring program.
- Identifies the qualifications required for various fire protection program personnel.

- Identifies the quality requirements of Chapter 2 of NFPA 805.

Detailed compliance with the programmatic requirements of Chapter 2 and 3 of NFPA 805 are contained in the NFPA 805 Fire Protection Program (Reference 43).

9.7 AUXILIARY FEEDWATER SYSTEM

9.7.1 DESIGN BASIS

The Auxiliary Feedwater System is designed to provide a supply of feedwater to the steam generators during start-up operations and to remove primary system sensible and decay heat during initial stages of shutdown operations. Equipment in the system is designed to CP Co Design Class 1 requirements (see Reference 3) with the exception of portions of steam supply piping to P-8B (Figure 9-13). As a result of lessons learned at TMI, the Auxiliary Feedwater System has been upgraded to a safety-related system and is used to remove decay heat during emergency shutdown operations.

9.7.2 SYSTEM DESCRIPTION AND OPERATION

9.7.2.1 System Description

The Auxiliary Feedwater System (AFW) supplies water to the secondary side of the steam generators for reactor decay heat removal when normal feedwater sources are unavailable. The system originally consisted of one electric motor-driven pump and one turbine-driven pump with piping, valves and associated instrumentation and controls. In 1983, a third high-pressure safety injection pump was converted to AFW service as the second electric motor-driven pump in the AFW system. Piping, valves and controls were added to provide redundancy of supply up to the containment penetrations where the redundant systems merge to form just two AFW lines - one to each steam generator (Figure 9-12). Each of the four lines in the redundant portion of the system, feeding the steam generators, contain one normally-closed, pneumatically-operated flow control valve and two locked open, de-energized motor-operated isolation valves; any one of the three pumps can feed one or both steam generators.

In 1988, flow control bypass valves were added around the flow control valves from P-8C. They were designed to allow continuous auxiliary feedwater at low flow rates during start-up and hot shutdown conditions. They are administratively controlled to operate only when the steam generator is cold or the level in the steam generator is 60% or greater to prevent the potential for water hammer.

All three AFW pumps normally take suction from the condensate storage tank. The minimum amount of water required in the condensate storage tank and primary coolant system makeup tanks combined (100,000 gallons) exceeds the amount needed for 8 hours of auxiliary feedwater pump operation for decay heat removal following a reactor trip. The condensate storage tank level is monitored in the control room. In addition, a low-level switch is provided to alarm at low water level which corresponds to a total tank inventory of 94,280 gallons. The primary system makeup tank provides an additional source of water to the AFW pump suction. A low-level switch is set to alarm at 65,580 gallons (total tank inventory) which assures that the required inventory of 100,000 gallons is available, even under gravity-feed conditions between the tanks (Reference 22). Control valves, CV-2008 and CV-2010 in the gravity feed line, can be manually operated to ensure adequate inventory is available at all times, including during loss of power and loss of instrument air. A crosstie from the fire system provides a backup water supply to the AFW pumps P-8A and P-8B. The third pump (Pump C) has a backup water supply from the Service Water System.

Minimum flow recirculation is provided through breakdown orifices which are designed to pass minimum pump design flow at maximum pressure. Administrative controls were established to limit the operation of AFW pump P-8C while in the recirculation mode (Reference 63).

The two original pumps are located in a tornado-proof CP Co Design Class 1 portion of the turbine building. Pump C is located in west engineered safeguards room in the auxiliary building. The supply header from the condensate storage tank and the tank are not protected from tornadoes, but the backup supplies from the diesel engine-driven fire pump and Service Water System are located in a protected area. The discharge header from the auxiliary feedwater pumps in the turbine building to the auxiliary building is buried underground.

9.7.2.2 Component Description

Design ratings and construction of components are shown in Table 9-12.

9.7.2.3 System Operation

During the initial phase of primary system cooldown, the Auxiliary Feedwater System supplies water to the steam generators to remove reactor sensible and decay heat. Core decay heat is transferred from the reactor to the steam generators by natural or forced circulation of the primary coolant. Steam from the steam generators is discharged through the bypass valve to the condenser. The steam can be discharged to the atmosphere in the event that the main condenser is not operable.

Either motor-driven auxiliary feedwater pump can be operated to provide auxiliary feedwater to the steam generators during start-up. Pump P-8C is normally used since its flow control valves have bypass valves which can control flow at lower flow rates. The level in the steam generators is maintained from the control room by remotely adjusting the auxiliary feedwater control valves in each respective steam generator auxiliary feed header.

The added motor-driven pump (Pump C) or the turbine-driven pump (Pump B) could supply auxiliary feedwater to the steam generators if Auxiliary Feedwater Pump A would fail. In the event of a loss of all AC power, the turbine-driven pump will start automatically on receipt of an AFAS signal or will be started from the control room and is used to supply feedwater to the steam generators. Upon a loss of DC power, the turbine driven pump will start automatically via the diverse start system added for ATWS during the 1990-91 refueling outage. The turbine-driven auxiliary feed pump and auxiliary feedwater control valves can also be operated locally. Driving steam for the turbine is supplied from the main steam header and the turbine exhaust steam is discharged to the atmosphere. The turbine can operate with steam generator pressures down to 38 psig and is protected by an overspeed trip set within 110% of maximum continuous speed. Steam traps were added in 1989 to resolve concerns regarding the starting of the turbine without draining the steam supply piping and the turbine casing. In 1996, the steam supply piping was reconfigured. A moisture separator was added and the existing steam traps were modified to improve moisture removal.

Auxiliary feedwater flow to the steam generators will be automatically initiated on a low-steam generator water level by the Auxiliary Feedwater Actuation System (AFAS). The normal valve positions on all valves of the suction side of the pumps, between the condensate storage tank and the pumps, are locked open and the steam admission valves to the turbine-driven pump are closed. The steam admission valve for the "A" steam generator (CV-0522B) has backup nitrogen upon loss of air and both steam admission valves can be manually operated. The flow control bypass valves associated with pump P-8C fail closed allowing control with flow control valves. The flow control valves fail open and those associated with pumps P-8A and P-8B have backup nitrogen upon loss of air. Additionally, all flow control valves can be manually operated. Safety grade flow rate indication for auxiliary feedwater flow to each steam generator is provided in the main control room. In the event of loss of offsite power, the motor-driven auxiliary feedwater pumps are enabled by the sequencers and started upon receipt of an AFAS signal. Power supplies for instrumentation and the motor-driven auxiliary feedwater pumps are discussed in Section 7.4 and Chapter 8, respectively.

In the event of loss or depletion of the water supply from the condensate storage and primary system makeup tanks, the backup water supplies from the fire system or Service Water System can be utilized by opening the hand valves in the crossties and, in the case of the fire systems, starting one of the fire pumps.

For any condition during which feedwater to the steam generators from the main feedwater pumps is interrupted and the reactor is tripped, sufficient feedwater flow is maintained by the motor-driven AFW pumps or the turbine-driven auxiliary feed pump to remove decay heat from the primary system and maintain the reactor in a safe condition.

In the event a steam line break occurs, the main feedwater pumps are inoperative. The turbine-driven auxiliary feed pump and the motor-driven auxiliary feed pumps are available to be used to maintain shutdown cooling flow to one steam generator. The Feed Only Good Generator (FOGG) actuation system was designed to terminate AFW flow to the affected steam generator. However, due to nuclear safety considerations, the automatic isolation feature has been disabled (Reference 2). The FOGG actuation system monitors steam generator pressure. Emergency Operating Procedures direct the operators to isolate the affected steam generator using the flow control valves.

9.7.3 DESIGN ANALYSIS

A loss of feedwater event is the bounding condition for the Auxiliary Feedwater System. For P-8A and P-8B the required flow is 270 gpm (135 to each) at 985 psig to both steam generators or 270 gpm at 985 psig to one steam generator. For Pump P-8C, the required flow for the loss of feedwater event is 270 gpm (135 to each) at 885 psig to both steam generators or 270 gpm at 885 psig to one steam generator. Operation of the turbine bypass system or atmospheric dump valves is required to depressurize to 885 psig. The preceding flowrates will remove decay heat and pump heat from four operating primary coolant pumps.

If offsite power is not available, the primary coolant pumps will trip, reducing the primary system heat load. The above required flow rate maintains sufficient Steam Generator inventory to support decay heat removal with natural circulation in the primary coolant system. When offsite power is available, the plant operators have sufficient time to take standard operator actions such as manually starting P-8A or P-8B for additional auxiliary feedwater flow or tripping all four primary coolant pumps to reduce heat load generation rate for the purpose of preserving steam generator secondary inventory.

9.7.4 SYSTEM RELIABILITY

System reliability is achieved by the following features:

1. Two motor-driven and one turbine-driven pumps are provided, any of which satisfy the requirements of primary system cooldown.

2. Pump motor power is supplied from offsite sources with backup supplied from the emergency diesel generators (see Subsection 8.4.1).

3. Steam is supplied to the turbine-driven pump from Steam Generator E-50A.

4. The condensate storage tank capacity is 125,000 gallons and is monitored to maintain a minimum storage of 94,280 gallons. A backup supply from the primary system makeup tank, fire, and Service Water System is provided to the auxiliary feed pump suction.

5. The condensate pumps may be used to pump water through the normal feedwater train to the steam generators in the event of a failure of the auxiliary feedwater piping system. The steam generator pressure may be relieved by the steam dump system to accommodate this mode of operation.

A reliability and operability review has been conducted by Consumers Power Company, the NRC and their consultants. The findings demonstrate that the AFW meets the NRC's long-term safety requirements.

9.7.5 TESTS AND INSPECTION

1. The auxiliary feedwater pumps are tested periodically during Plant operation by starting each pump, establishing test reference conditions and monitoring pump performance.

2. Each nonautomatic valve in the flow path that is not locked, sealed or otherwise secured in position is periodically inspected to verify its correct position.

3. The diaphragm-operated flow control valves in the auxiliary feedwater pump discharge piping are exercised periodically during Plant operation to ensure proper functioning.

4. The automatic initiation function of the Auxiliary Feedwater System is periodically tested by simulating a low-steam generator level and observation of pump start. Operability of the diaphragm-operated 4-inch flow control valves is verified by initiating Auxiliary Feedwater flow and observing valve actuation to its correct position or by monitoring for proper Auxiliary Feedwater System flow. Operability of the 1½-inch bypass valves is verified by observing the valves closing when control is taken by the 4-inch flow control valves.

5. Inservice inspection and testing is conducted in accordance with Section XI of the ASME B&PV Code. Inservice testing is conducted in accordance with the ASME OM Code.

6. All Auxiliary Feedwater System components outside containment are accessible for inspection during Plant operation.

7. A 48-hour endurance test has been performed on the auxiliary feedwater pumps. The results demonstrated that the pumps performed in an acceptable manner without exceeding design limits.

8. Inspections are performed to detect potential disabling of the AFW pumps by steam binding due to back leakage of main feedwater past the isolation check valves between the AFW and MFW system (Reference 30).

9.8 HEATING, VENTILATION AND AIR-CONDITIONING SYSTEM

9.8.1 DESIGN BASIS

1. The Heating, Ventilation and Air-Conditioning System is designed to provide a suitable environment for equipment and personnel. The path of air for ventilating systems in potentially radioactively contaminated areas runs from areas of low activity toward areas of progressively higher activity for ultimate discharge from the Plant via the ventilation stack. The condensate and makeup demineralizer building HVAC system is also designed so air flows from areas of low potential airborne radioactivity to areas of higher potential airborne radioactivity. High-efficiency air filters are provided for the exhaust.

2. The design is based upon the ambient conditions listed in Table 9-13.

3. The containment building, radwaste area and fuel handling area are designed for containment of radioactive particles. The exhaust air from these areas is ducted to high-efficiency filters to assure minimum activity levels for the stack discharge and to maintain containment of radioactive particles in those areas of possible contamination. The fuel handling area also has a charcoal filter in parallel with the high-efficiency filter which may be placed in operation during fuel handling operations or heavy load movements.

4. The control room Heating, Ventilation and Air-Conditioning (HVAC) System was modified in 1983 in response to NUREG-0737, Item III.D.3.4. The design bases for the system are as follows:

    a. During emergency mode operation, the control room HVAC system maintains a positive pressure in the control room, TSC, viewing gallery and mechanical equipment room in order to limit control room envelope unfiltered inleakage to a value less than or equal to the value assumed in the analyses of design basis accidents. The control room HVAC system maintains a dry bulb temperature as indicated in Table 9-13.

    b. The control room HVAC system is designed to permit periodic inspection, testing and maintenance of principal components with minimal interruption of normal control room operation.

    c. The control room HVAC system is designed to limit the radiation exposure of control room personnel during any of the postulated design basis accidents within the guidelines of 10 CFR 50, Appendix A, General Design Criterion 19.

d. Throughout the duration of any design basis accidents, the control room HVAC system maintains control room environmental temperatures suitable for prolonged occupancy and continued operation of safety-related equipment.

e. The failure of an active component in the control room HVAC system, assuming a loss of offsite power, cannot impair the system's ability to meet the design bases discussed in Paragraphs c. and d. above.

f. The control room HVAC system is designed to remain functional during and after a safe shutdown earthquake.

g. The control room HVAC system is designed to remain functional during and after a design basis tornado.

9.8.2 SYSTEM DESCRIPTION AND OPERATION

9.8.2.1 System Description

Plant equipment spaces are ventilated and cooled with ambient outside air. The outdoor design maximum is 95°F. A space temperature of 110°F is the design limit for personnel occupancy. Indoor and outdoor HVAC design basis ambient conditions are presented in Table 9-13. This table also reveals areas that have maximum indoor temperatures that exceed 110°F. The ventilation systems are either induced draft using motor-driven roof exhausters or forced draft fan and duct distribution systems. Spot cooling of equipment is used where it is impractical to cool the entire space. The HVAC systems are shown in Figure 9-14.

Airflow controllers are used to maintain negative differential pressures in equipment compartments and between controlled and noncontrolled spaces in the auxiliary building and auxiliary building addition. This negative pressure is used to induce infiltration into compartments thus producing a predictable direction of airflow toward areas of increasing radiation hazard. Final exhaust from these potentially contaminable compartments is discharged to atmosphere through the ventilation stack after filtering out radioactive particulate matter in a high-efficiency filter. The fuel handling area exhaust has a charcoal filter in parallel with the high-efficiency filter which is placed in operation during fuel handling operations.

The Plant normally uses extraction steam, from the low-pressure turbine, reduced to 15 psig for Plant heating. The two auxiliary heating boilers are available for use during Plant shutdown. Each boiler has the capacity to satisfy minimum shutdown heating requirements at the minimum outdoor design temperature of –10°F. A third boiler in the feedwater purity building can be tied into the system if required.

The total control room HVAC system, shown schematically in Figure 9-14, Sheets 5, 6 and 7, consists of two trains of air handling, air filtering units and Continuous Air Monitor (CAM) units (Train A and Train B), the purge exhaust system, toilet exhaust system, and associated ductwork, dampers, instruments and controls.

To reduce noise levels, acoustical diffusers were installed at the HVAC duct outlet supplies to the office and Control Room Supervisor's areas. An acoustical silencer was installed in the main supply duct to the Control Room. Both modifications provided effective noise reduction in the main Control Room.

A CP Co Design Class 1 mechanical equipment room (MER) (located above the emergency diesels) is provided to house the HVAC equipment. The equipment room is divided into two compartments separated by a 3-hour fire barrier. All components of one train are located in one compartment to meet the redundancy criteria. The MER is part of the control room envelope.

The major components of Train A are an air handling unit (V-95), a condensing unit (VC-11), one Continuous Air Monitor unit (consists of sampling head RE-1818A, display/processing unit RIA-1818A and air pump P-968A), one charcoal filter unit (VF-26A) and associated fan (V-26A). Dampers associated with Train A are D-1, D-2, D-3, D-4, D-5, D-6, D-7, D-20 and Tornado Dampers TD-1 and TD-4.

The major components of Train B are an air handling unit (V-96), a condensing unit (VC-10), one Continuous Air Monitor unit (consists of sampling head RE-1818B, display/processing unit RIA-1818B and air pump P-968B), a charcoal filter unit (VF-26B) and an associated fan (V-26B). Dampers associated with Train B are D-8, D-9, D-10, D-11, D-12, D-13, D-14, D-21 and Tornado Dampers TD-2 and TD-5.

The purge exhaust system consists of Fan V-94, Isolation Dampers D-15 and D-16 and Tornado Damper TD-3. Toilet exhaust system Fan V-16 has Isolation Dampers D-17 and D-18 and Tornado Damper TD-6.

During normal mode operation, DPIC 1659 and 1660 control positive pressure in the control room envelope with respect to the relative pressure of the south hallway outside the control room viewing gallery.

Four humidity detectors are provided in the containment building to detect leakage from the Primary Coolant System and the main steam lines. The relative humidity measured by these detectors is indicated in the control room.

Cooling water for the containment air coolers, the engineered safeguards room coolers and the condensing units and water chiller is Plant service water.

The ventilation and air-conditioning control systems use pneumatic-type controllers with pneumatic-electric switching devices to interconnect the equipment and the controls. Instrument air for the controllers is taken from the Plant instrument air system.

9.8.2.2 Component Description

The design data for the major components in the control room HVAC system are listed in Table 9-14.

1. Air Handling Units V-95 and V-96

   Each air handling unit consists of a medium efficiency filter, an electric heating coil, a refrigerant cooling coil, a centrifugal fan and associated ductwork, instrumentation and controls. The electric heating coil is not normally utilized since the control room heat load is adequate to maintain air temperature. A steam injection grid is located in the supply ductwork after the airflow measuring unit for each air handling system.

2. Condensing Units VC-10 and VC-11

   The water-cooled condensing units supply refrigerant to the cooling coil of Air Handling Units V-95 and V-96, as required. Cooling water to the condensing units is supplied from the Plant service water.

3. Charcoal Filter Units VF-26A and VF-26B

   The 3,200 ft^3/min capacity charcoal pressurization/recirculation filter units are provided for emergency operation. Each filter train consists of medium efficiency prefilters, an electric heating coil, upstream high-efficiency particulate air (HEPA) filters, two banks of 2-inch carbon adsorber trays, downstream HEPA filters, a vaneaxial fan, an electric modulating damper and associated ductwork, instrumentation and controls.

4. Humidifiers VH-12 and VH-13

   A 50 lb/h capacity humidifier is provided for each air handling unit. The humidifier consists of a steam generator, with high water cutoff and steam dispersion tubes for installation in the ductwork.

5. Bubble-Tight Isolation Dampers

Damper D-1 and D-2 are series dampers which provide isolation of the normal air intake on Train A. Dampers D-8 and D-9 are series dampers, of the same design, which provide isolation of the normal air intake on Train B. Dampers D-15 and D-16 are series smoke purge isolation dampers. All of these dampers are leakage class “bubble-tight” (Reference 24) and are designed to prevent seat leakage at a design operating pressure of 4.0 inches of water. These dampers have air-operated actuators with fail-close features.

6. Continuous Air Monitors

A Continuous Air Monitor unit in installed in each Control Room HVAC equipment room. Each CAM unit consists of sampling head RE-1818A (Train A), RE-1818B (Train B), display/processing unit RIA-1818A (Train A) RIA-1818B (Train B) and air pump P-968A (Train A) P-968B (Train B). Each CAM unit is installed with stainless steel tubing sample lines to monitor each outside air intake downstream of the outside air isolation damper and alarm on airborne radioactivity.

9.8.2.3 Codes

1. The work, equipment and materials for the original Plant HVAC system design conform to the requirements and recommendations of the following codes and standards as applicable:

   a. The work and materials conform to the American Society of Heating, Refrigeration and Air Conditioning Engineers Guide (ASHRAE).

   b. The fans conform to the Air Moving and Conditioning Association, Inc, standards, definitions, terms and test codes for centrifugal, axial and propeller fans.

   c. The work, equipment and materials conform to the National Fire Protection Association Pamphlet 90A, "Air Conditioning, Warm Air Heating, Air Cooling Ventilating System."

2. The work, equipment and materials for the control room HVAC modifications made in 1983 conform to the requirements and recommendations of the following additional guides, codes and standards, as applicable:

   a. Ventilation ductwork conforms to applicable sections of the Sheet Metal and Air Conditioning Contractors National Association (SMACNA) manual.

b. Refrigerant cooling coils conform to the standards of the Air Conditioning and Refrigeration Institute (ARI) and to requirements for Seismic Category I equipment.

c. Applicable components and controls conform to the requirements of Underwriters Laboratories (UL), the National Electric Manufacturers Association (NEMA) and the Institute of Electrical and Electronics Engineers (IEEE) Standards 323, 344 and 383.

d. Charcoal filter units and the associated ductwork, dampers and controls conform to the applicable sections of American National Standard Institute (ANSI) Standard 509-1980 and Standard 510-1980.

3. Control room dampers D-1, D-2, D-8, D-15, and D-16 are bubble-tight dampers that conform to the applicable sections of American Society of Mechanical Engineers (ASME) AG-1, Code on Nuclear Air and Gas Treatment (Reference 24).

9.8.2.4 <u>Operation</u>

1. The HVAC systems are shown in Figure 9-14.

2. The operation of the air handling units for the turbine building is as follows:

   a. Each unit has one steam coil downstream of a mixing box. The mixing box dampers and steam coil are controlled to provide a 60°F supply air temperature.

   b. If the fan motor is shut off, the fresh air inlet dampers will close.

   c. During normal operation, air is supplied to the auxiliary feed pump room by one of the turbine building air handling units and air is exhausted back to the main turbine building space via an exhaust duct located in the ceiling of the auxiliary feed pump room.

3. Steam-operated unit heaters are provided to heat the turbine building and other areas as needed. Steam-operated unit heaters are also provided to heat containment, however, the steam supply is a manual function. Furthermore, a design modification cut and capped the steam supply and return to these unit heaters. A design modification could restore this system if it is needed in the future. On all of the unit heaters when heat is required, a thermostat starts the fan automatically.

4. Roof exhausters are provided for the turbine building, feedwater area, intake structure and boiler room. Thermostats set at preset temperatures individually start the roof exhausters so that all roof exhaust fans will be operating at a maximum temperature of 104°F.

5. Wall supply fans in the feedwater area and in the vicinity of the condensate pumps are started at preset temperatures by thermostats mounted in the area.

6. The supply unit mounted on the intake structure will operate continuously supplying a mixture of outside and return air. Wall supply fans are started at preset temperatures by thermostats mounted in the area.

7. The supply units for the diesel generator room supply fresh air as the cooling load requirements demand. These fans are started automatically in sequence by thermostats.

8. Operation of the air supply units for the fuel handling area and the radwaste area is as follows:

    a. Each air supply unit is equipped with steam coils, a preheat coil and a reheat coil, and an air filter.

    b. The two steam coils function to maintain supply air temperature appropriate for the area supplied from each fan.

    c. A thermostat senses the preheat coil leaving air temperature and closes an alarm circuit on low temperature to signal faulty coil performance. The alarm is located in the control room HVAC panel.

    d. If the fan motor is shut off, the fresh air inlet dampers close.

9. The operation of the auxiliary building office air-conditioning unit is as follows:

    a. Air is recirculated and mixed with fresh air to provide a mixed air temperature of 60°F.

    b. The steam coil and chilled water cooling coil in the air-conditioning unit are controlled by a thermostat in the supply fan discharge flow path.

    c. The supply airflows remain nearly constant but the fresh airflow varies depending upon the setting of the occupancy selector switch and the mixed air thermostat.

    d. If the fan motor is shut off, the fresh air inlet dampers close.

10. The duct heaters for both the auxiliary building systems and the turbine building offices are controlled by room thermostats to obtain the desired room temperatures.

11. The access control duct cooling coil is controlled by the same thermostat that controls the duct heater.

12. The control room HVAC system operates in three different modes to meet the design bases discussed in Subsection 9.8.1. The three modes of operation (normal, emergency and purge) are described in Paragraphs a. through c. below. Tornado protection is described in Paragraph d. below:

    a. Normal Mode

       During normal mode operation, either Train A or Train B operates to supply air to the control room, Technical Support Center (TSC) and viewing gallery, and maintains a positive pressure with respect to the surroundings.

       When Train A is in operation, Air Handling Unit Fan V-95 supplies conditioned air to the control room, TSC and viewing gallery. The room differential pressure controller modulates Damper D-2 to bring in a sufficient amount of outside air to maintain a positive control room pressure. Control room temperature is maintained by two 2-stage thermostats located in the control room, which control Condensing Unit VC-11 by unloading cylinders. Dampers D-1 and D-2 are interlocked with the air handling unit fan to open when the fan is running and to close when the fan is stopped. A humidistat controls the humidity to 40% relative humidity (design basis is 50% relative humidity). Humidifiers are interlocked with a high limit humidistat and with the fan.

       The Train A damper positions during normal mode operation are as follows:

       (1) Dampers D-5, D-6 and D-7 close.

       (2) Dampers D-1, D-3, D-4 and D-20 open.

       (3) Damper D-2 modulates.

The Train B damper positions during normal mode operation are as follows:

(1) Dampers D-12, D-13 and D-14 close.

(2) Dampers D-8, D-10, D-11 and D-21 open.

(3) Damper D-9 modulates.

Dampers D-1, D-2 and D-4 isolate Air Handling Unit V-95 of Train A from the outside and Train B when Train A is not in operation.

Dampers D-8, D-9 and D-11 isolate Air Handling Unit V-96 of Train B from the outside and Train A when Train B is not in operation.

When Train B operates, Air Handling Unit V-96 supplies conditioned air to the control room, TSC and viewing gallery. The room differential pressure controller modulates Damper D-9 to bring in a sufficient amount of outside air to maintain positive pressure in the control room. Control room temperature is maintained by two 2-stage thermostats located in the control room, which control Condensing Unit VC-10 by unloading cylinders. Dampers D-8 and D-9 are interlocked with the air handling unit fan to open when the fan is running and to close when the fan is stopped. A humidistat controls the humidity to 40% relative humidity (design basis is 50% relative humidity). Humidifiers are interlocked with a high limit humidistat and with the fan. A smoke detector is provided for each train (E/U-351 - Train A, E/U-352 - Train B) in the normal fresh air intake to the Air Handling Unit. The smoke detectors are located between the tornado damper and the outside air dampers and is used to provide the operator with indication that smoke is being drawn into the Control Room from the fresh air intakes.

b. Emergency Mode

The emergency mode of operation is actuated either by a containment high-radiation or a containment high-pressure signal (Section 7.3), or manually from the control room. During emergency mode operation, the air handling units and the charcoal filter units of both Train A and Train B operate. The refrigerant Condensing Units VC-10 and VC-11 shut down and are manually started by the operator. The control room operator has the option to turn off either Train A or Train B. During an emergency signal, operation of Purge Fan V-94 and Isolation Dampers D-15 and D-16 is blocked. The toilet exhaust fan in the viewing gallery is shut off, and Fan Isolation Dampers D-17 and D-18 close. A manual switch to override each outside air duct damper (D-7 and D-14) is provided to isolate the control room from outside air and to allow 100% air recirculation. Humidifiers VH-12 and VH-13 are shutdown to isolate domestic water vapor from affecting HEPA filtration as well as charcoal filter absorbtion. VHX-26A and VHX-26B, electric heaters upstream of the emergency HEPA and Charcoal filters, are placed in service to reduce relative humidity of incoming air.

The Train A damper positions during emergency mode operation are as follows:

(1) Dampers D-1, D-2, D-17 and D-18 close.

(2) Dampers D-3, D-4, D-5, D-6 and D-7 are fully open.

(3) Damper D-20 modulates.

Air Handling Unit V-95 takes return air from the control room, TSC and viewing gallery, conditions it, and returns it to maintain the desired temperature in the control room. Filter VF-26A (which has a capacity of 3,200 ft^3/min) admits 1,000 ft^3/min outside air through the emergency outside air intake duct and admits 2,200 ft^3/min from the control room return air duct. The 3,200 ft^3/min filtered air is then supplied to the control room via Air Handling Unit V-95. Positive pressure of nominally .125" of water or greater is maintained in the control room by adding the 1,000 ft^3/min outside air to the system. A constant flow rate through the filter unit is maintained by modulating Damper D-20 to compensate for filter loading.

Train B emergency operation is similar to Train A. The Train B damper positions during emergency mode operation are as follows:

(1) Dampers D-8, D-9, D-17 and D-18 close.

(2) Dampers D-10, D-11, D-12, D-13 and D-14 are fully open.

(3) Damper D-21 modulates.

Air Handling Unit V-96 takes return air from the control room, TSC and viewing gallery, conditions it, and returns it to maintain the design temperature in the control room.

Filter VF-26B operation is similar to V-26A operation. Filter VF-26B recirculates 3,200 ft^3/min and pressurizes the control room by bringing in 1,000 ft^3/min outside air.

c. Purge Mode

Smoke can be purged from the control room by Fan V-94. This fan is manually started by the operator, when required. When the purge fan is started (with V-95 running), Dampers D-15 and D-16 open; Return Damper D-3 closes; and Dampers D-1 and D-2 open fully to bring in 9,060 ft^3/min outside air and prevent recirculation. When the purge fan is started (with V-96 running), Dampers D-15 and D-16 open; Damper D-10 closes; and Dampers D-8 and D-9 open. Purge Fan V-94 exhausts 7,800 ft^3/min to the atmosphere, 160 ft^3/min is exhausted by the toilet exhaust fan and 1,100 ft^3/min exfiltrates.

When the purge fan runs in conjunction with Train A, the damper positions are as follows:

(1) Damper D-3 closes.

(2) Dampers D-1, D-2, D-15 and D-16 open.

When the purge fan runs in conjunction with Train B, the damper positions are as follows:

(1) Damper D-10 closes.

(2) Dampers D-8, D-9, D-15 and D-16 open.

d. Tornado Protection

Tornado dampers are provided in all the outside air intakes, the purge exhaust and the toilet exhaust ducts. During tornado depressurization, the tornado dampers close to isolate the HVAC system from the outside.

e. Control Room/TSC Envelope

Four vestibules are used to provide egress and ingress to the control room/TSC during post-accident operations. These vestibules are adjacent to Doors 108, 115, 175 and 52. Their function is to prevent air in-leakage.

f. Penetrations to the Control Room Envelope

Uncontrolled open penetrations to the control room/TSC envelope degrades the maintenance of positive air pressure. Therefore, administrative controls are used for maintenance activities requiring an open penetration. These controls assure prompt and secure closure of openings in the event of an emergency.

The Thermal Margin Monitor (TMM) was originally qualified to 131°F. However, the location of the TMM in the panel is such that cooling is required. Analysis shows that, with forced air cooling, 131°F is reached by the TMM when the control room ambient temperature is 106°F. Because the TMM portion of the RPS is no longer capable of operating at the nominal control room design temperature of 120°F, a control room administrative limit of 90°F was imposed.

Other portions of the Reactor Protective System located in the control room were designed to operate up to 135°F and 90% relative humidity. Individual components and modules of the RPS have been factory tested at design temperature and humidity conditions. With the exception of the TMM, the RPS cabinet (including all portions of the system located in the control room) has been tested for operation as a system at temperatures in excess of 135°F.

Other electronic equipment used in plant safety-related components can operate at 120°F continuously and at 140°F intermittently as proven by experience.

Cooling of safety-related equipment and controls located in rooms other than the main control room is maintained by systems designed with similar component redundancy as the control room air-conditioning system.

13. The engineered safeguards equipment room coolers are started by a signal from wall-mounted thermostats and provide cooling for the protection of the engineered safeguards equipment. Service water flow is continually maintained through the cooling coils by maintaining CV-0878 and CV-0825 electrically locked open. The valves are operated by cylinder lock hand switches preventing inadvertent closure.

    Each room has one cooler with two fans, one powered from Class 1E MCC-1 and the other powered from Class 1E MCC-2. Emergency power for each cooler is supplied upon loss of offsite power from diverse sources. MCC-1 and MCC-2, which provide diverse power sources for the fans in each room, are automatically loaded on EDG 1-1 and EDG 1-2 respectively. Equipment located in these rooms are the HPSI pumps, containment spray pumps, LPSI pumps, shutdown cooling heat exchangers, high-pressure control air equipment, and related piping, valves and controls.

    As a result of Consumers Power Company's evaluation of IE Bulletin 80-06, "Engineered Safety System (ESF) Reset Controls," circuitry modifications were made to ESF Room Cooler Valves SV-0825 and SV-0878 such that these valves do not close upon an ESF reset signal. In addition, to preclude inadvertent closure of the service water valves supplying cooling to the ESF room coolers, the hand switch controllers (HS-0825A and HS-0878A) for these valves were changed from hand switches without locks to hand switches with cylinder lock operators.

    V-27B, V-27C and associated room cooler are considered to be necessary components required during accident conditions. The HPSI pump and Containment Spray pump(s) are inoperable if its room cooler or associated fan powered from the same D/G as the pump is declared inoperable.

    Since the LPSI pumps are not required to operate beyond RAS, when the large heat load in the rooms commences, functioning of the fans and coolers is not necessary to support LPSI pump operability. The P-8C is not required for those accident scenarios where the recirculation mode is used, functioning of the fan and cooler is therefore not necessary for pump P-8C operability. The HPSI pumps are necessary for both “residual heat removal” and “emergency core cooling” by the accident analysis. The containment spray pumps are required for “containment heat removal” by the accident analysis. Since the containment spray pumps and the HPSI pumps are required by the accident analysis post RAS, ie, when the greatest heat load exists, they are dependent on the room temperature and the room coolers for continued operation. Therefore, the room coolers and associated fans are required to be operable to support operability of the required equipment to support the accident analysis (EA-D-PAL-93-272F-01).

14. Two iodine removal filter units were installed for preoutage containment atmosphere iodine removal. The units are freestanding and do not use inlet or outlet ductwork. Each fan has an attached silencer to reduce noise in containment. The units are manually operated when required.

15. The containment purge and vent system is operated only during cold shutdown conditions. The operation of the system is as follows:

    a. One main exhaust fan (V-6A or V-6B) must be running.

    b. Purge isolation valves (CV-1805 and CV-1806, and/or CV-1807 and CV-1808) are opened.

    c. Air room supply isolation valves (CV-1813 and CV-1814) are opened and air room purge supply fan (V-46) is started. During cold weather heat is supplied by Heating Coil VHX-48.

    d. The purge system is stopped by reversing the above procedure.

    Containment integrity is not required when the plant is in a cold shutdown condition and the normal CHP/CHR are not required to be operational. However, during refueling operations, refueling radiation monitors must be in operation and occurrence of a high radiation condition will initiate a CHR signal and close the containment purge isolation valves.

16. The radwaste area exhaust system operates as follows:

    a. Normally both fans, each rated at 50% of the normal flow, operate continuously. Dampers in the fan discharge modulate to maintain a uniform static pressure in the filter intake plenum.

    b. The filter intake pressure is the static pressure of a balanced airflow from all areas with access openings closed or in the normal condition. The ductwork is sized to permit airflows from the cells through access ports sufficient to permit entrainment velocities. Thus, if an access port or hatch cover is open, the air velocity through the opening is over 100 feet per minute and the fan discharge dampers will open to maintain the set static pressure at the filter intake plenum.

    c. Hoods have high-efficiency particulate filters as an integral part of the hood, and booster fans are provided to offset the pressure drop through the filter.

d. In the event of an exhaust fan failure, the supply fan may be shut down and the negative pressure of the radwaste area will be maintained by the remaining exhaust fan.

e. In the event of failure of the radwaste area supply fan, one of the exhaust fans is automatically shut down but the pressure control apparatus will limit the amount of the negative pressure developed by the lack of supply air and prevent excessive pressure differentials.

f. In the event of a spillage of radioactive material in the radwaste area, the radiation monitor at the filter plenum senses the activity and stops the supply fan, closes the radwaste area supply Damper PO-1809, and stops the selected exhaust fan; however, a low flow alarm will override the high radiation signal and keep the standby exhaust fan running. The duct to access control remains open and is isolated from the radwaste area by Damper PO-1809.

g. In the event of significant airborne contamination in the engineered safeguards rooms, the supply and exhaust dampers of those rooms are closed on a signal from the individual non 1-E radiation monitor for each exhaust duct.

17. The fuel handling area exhaust system operates as follows:

a. During normal operation, one or both of the exhaust fans run, as required, and draw air through a prefilter and a high-efficiency filter.

b. During refueling operations, the exhaust air may be diverted through a prefilter, HEPA filter and a charcoal adsorber bed. This filter train is parallel to the normal high-efficiency filters and is isolated from it by the positioning of an inlet damper.

c. In the event of a fuel handling/cask (heavy load) drop accident in the spent fuel pool, the exhaust airflow is reduced to one-half by tripping the supply fan and closing the inlet damper and tripping one of the 50% capacity exhaust fans. The exhaust air flows through the high-efficiency particulate filter and a charcoal filter. See Sections 14.11 and 14.19 for specific assumptions of the Fuel Handling Building HVAC used in the safety analysis.

18. The operation of the auxiliary building addition fuel handling supply and radwaste supply is as follows:

    a. The supply unit for each area is equipped with a preheat coil, a reheat coil and an automatic filter.

    b. The preheat coil is controlled by a thermostat in the fresh air intake set at 35°F. The reheat coil is controlled by a leaving air thermostat to maintain a discharge temperature of 60°F.

    c. Another thermostat is provided in the leaving air stream which is set at 45°F and alarms in the control room when this temperature is reached to indicate faulty coil performance.

    d. If the fan motor is shut off, the fresh air inlet dampers close.

    e. The supply fans will trip on a high-radiation signal from radiation monitors located in the corresponding exhaust system ducts.

19. The operation of the auxiliary building addition fuel handling area exhaust and radwaste exhaust systems is as follows:

    a. The exhaust systems each consist of a filter package which contains a bank of roughing filters and a bank of HEPA filters. Air is drawn through the filter plenum by two exhaust fans.

    b. Normally both fans, each rated at 50% of the normal flow, operate continuously. Dampers in the fan discharges modulate to maintain a uniform static pressure in the filter intake plenum.

    c. In the event of an exhaust fan failure, the supply fan may be shut down and the negative pressure of the area served by the particular system will be maintained by the remaining exhaust fan.

    d. In the event of failure of a supply fan, one of the exhaust fans will shut down but the pressure controller in the filter intake plenum will limit the amount of negative pressure developed by the lack of supply air and prevent excessive pressure differentials.

    e. In the event of release of radioactive material in the area served by the system, the radiation monitor at the filter plenum senses the activity and trips the supply fan which in turn trips one of the exhaust fans. However, a low flow condition will override the high-radiation signal and keep the standby exhaust fan running.

f. In the event of a radioactive release in the fuel handling area, Operations takes manual actions to secure the auxiliary building addition fuel handling area supply and exhaust. Additionally, administrative actions are in place to close the equipment hatch and the personnel airlock within a specified time. Further, other area boundary doors are controlled or maintained closed during fuel handling operations.

20. The penetration and fan rooms' heating and ventilating system has been installed as part of the high-energy line work heating and ventilation. This system provides cooling air to the feedwater pipe penetration room and fan room. This system is not considered essential because the essential equipment located in this area is qualified to survive a main steam line break within this area. The system operates as follows:

    a. The supply system consists of a supply fan, an air filter and an outside air damper.

    b. The exhaust system consists of a prefilter, a high-efficiency filter and an exhaust fan.

    c. The supply and exhaust systems run concurrently and are controlled by a thermostat located in the exhaust duct. The supply and exhaust fans are started when the exhaust air temperature is 90°F and stop when the exhaust air temperature is 70°F.

    d. A differential pressure controller which measures differential pressure across the filters and filter inlet damper, modulates the filter inlet damper to maintain a preset negative pressure across the filters and dampers.

21. The electrical equipment, switchgear, cable spreading and battery rooms' HVAC system was modified in the 1983 outage to include the new electrical equipment room added as part of the control room modification work. This system formerly served the viewing gallery. This system operates as described below and serves the following areas:

    Electrical Equipment Room
    Cable Spreading Room
    Bus 1D Switchgear Room
    Bus 1C Switchgear Room
    Battery Room

The cable spreading room, switchgear rooms and battery rooms are considered essential because they house the reactor protection and control system, the instrumentation for shutdown and cooldown, the emergency power (ac and dc) and control power for safe shutdown systems all of which are considered important to safety.

The ventilation system that services these areas is composed of V-33 and V-43 with supplemental ventilation supplied by V-47, none of which are safety grade. Supply Fan V-33 provides 18,500 scfm of air to the areas identified. Makeup air to V-33 is a blend of outside air and recirculated air from V-43. This blend is controlled by a mixed air temperature controller. When outside air temperature increases, the amount of recirculation is decreased, and the amount of makeup increases up to the full 18,500 scfm.

The Cable Spreading Room is equipped with a duct mounted type smoke detector E/U-238E. It is located in the duct downstream of recirculating fan V-43 and damper CD-19. It's function is only to provide an indication to the operator that smoke is being drawn from the Cable Spreading Room.

The duct branch that services the new electrical equipment room is equipped with a chilled water cooling coil to provide adequate cooling for the room. This cooling coil is controlled by a thermostat located in the electrical equipment room.

Separate from this two-fan ventilation system is a 30,000 scfm exhaust fan that takes suction on the cable spreading, Bus 1D switchgear and Bus 1C switchgear rooms only. When air temperature in the upper region of the rooms increases above 100°F, Temperature Switches 1824, 1825 and 1826 will initiate a control room annunciator none of which are safety grade. During normal plant conditions, the operator may manually start the supplemental Exhaust Fan V-47. Normally, the temperature will drop below the 100°F set point within 10 minutes and the operator will stop V-47. When the control room ventilation system is in its emergency mode, V-47 is not operated because its high suction capacity inhibits the ventilation system from maintaining its required positive pressure.

If the high-temperature alarm does not clear, other corrective measures available to the operator would be: check fan and damper operation, ensure heating steam controller and cooling controllers are functioning, ensure filter media is clear, block open doors, place fire protection smoke blowers in rooms as temporary air movers.

22. The containment building air coolers operate as follows under normal conditions:

    The service water supply line for each safety-related cooler has an air-operated stop valve which is electrically locked open. The return line for each safety-related cooler has an 8" air-operated discharge valve which is usually (in cold weather) held closed and a 4" temperature control valve in a bypass line around the closed discharge valve. The normal operating position of the service water discharge valve for VHX-3 is open to preclude the potential for silt/sand buildup on the closed valve disc which may cause valve binding (Reference EAR-2002-0027). The non-safety related cooler (VHX-4) has air-operated valve in its service water supply and return lines that are normally open. The VHX-4 return line valve can be closed during cold weather to reduce the cooling occurring in containment. The service water supply and discharge valves for all the coolers go to their safety position upon loss of control power or instrument air. The 4" temperature control valves were modified by SC-93-054 to eliminate the automatic temperature control function. These valves may be manually operated locally using the provided air regulator but are typically kept full open (with the exception of VHX-4's TCV, whose air supply has been isolated per FC-713, failing it closed). Because the temperature control function was eliminated, the valve equipment ID’s are now CV rather than TCV. The supply and 8" discharge valves may be manually operated from the main control room and the engineered safeguards local panel. The bypass valves can only be closed from the control room by isolating instrument air to containment.

    Air is drawn through the containment air coolers by two matched vaneaxial fans with direct connected motors. One fan motor is rated for normal conditions and the second is rated for post-DBA conditions. During normal operation the total airflow through each cooler is 60,000 CFM. The fan motors, rated for the post-DBA condition are fed from the emergency power buses. All fans may be manually started or stopped from the main control room or at the individual breakers. For description of the operation under accident conditions, see Section 6.3.

23. The CRDM cooling system consists of two fans which draw in building ambient air and discharge it into a shroud around the CRDMs.

24. The containment post-accident filter system is described in Section 6.5.

25. The main steam line and feedwater line containment penetration cooling system consists of two fans which draw air from the 590 ft elevation CCW room and discharges it through passages in the annulus between the pipe and concrete.

26. Operation of the condensate and makeup demineralizer building HVAC system is as follows:

    a. The heating and ventilation air handling units perform the ventilation and heating function for the condensate and makeup demineralizer building areas. The systems are designed to take outside air, mix it with return air as applicable, filter it at the air handling unit and distribute it to the building areas. Areas being served by the heating and ventilating air handling units are provided with thermostats for control of winter space temperatures. Exhaust airflows are from areas of low potential airborne radioactivity to areas of higher potential airborne radioactivity.

    b. The instrument room air-conditioning unit provides cooling and heating for the instrument room. The system is designed to take outside air, mix it with return air, filter it, and deliver it to the instrument room. A space thermostat is provided for heating temperature control. The system is equipped for economizer control for room cooling.

    c. The boiler room supply fan and roof exhauster perform the ventilating function for the boiler room. The equipment supplies outside air and exhausts hotter room air. The fans are started and stopped by room thermostats or may be operated manually by a control switch.

    d. The air compressor and switchgear room and the pipe gallery use wall louvers and roof ventilators for ventilation. The systems are started and stopped by room thermostats or may be operated manually with control switches.

    e. Unit heaters are controlled individually by room thermostats.

27. Operation of the Volume Reduction and Solidification (VRS) area HVAC systems are as follows:

    a. The VRS area control room air-conditioning unit provides cooling for the VRS area control room. The system is designed to take room return air, mix it with minimum outside air, filter and cool the air as necessary and deliver it to the VRS system control room. The air-conditioning unit is controlled from a room thermostat. Redundant condensers are provided for the air-conditioning unit for reliability.

    b. The VRS area supply air system consists of an air-conditioning unit with an air-cooled condenser. Outside air is drawn through the unit, filtered and cooled as necessary and delivered to the space. A space thermostat controls operation of the unit.

    c. The VRS area exhaust system consists of a duct system which is tied into the existing radwaste area exhaust system. The air supplied to VRS area is drawn through the space and exhausted to the outside through the radwaste area exhaust filter (VF- 73).

9.8.3 TESTS AND INSPECTIONS

Provisions for testing equipment performance are built into the critical apparatus such as exhaust systems, the engineered safeguards room coolers and the control room air-conditioning unit and refrigerant condensers. After the equipment is installed and operating, periodic tests may be performed to assure that filters and coils are not dirty or plugged and the unit is still performing as required.

The charcoal and high-efficiency filters for the control room and the fuel handling area are tested per the requirements of the Technical Specifications.

9.8.4 LOSS OF INSTRUMENT AIR TO VENTILATION DAMPERS

Table 9-15 lists the ventilation dampers, their function, and positions during operation of the Plant under normal, shutdown, abnormal conditions and loss of instrument air. Particular attention has been given to the failed position of dampers to ensure maximum safety of Plant personnel and minimum emission of possible contaminants to the environment.

The control room HVAC system damper positions for the various modes of operation are discussed in Subsection 9.8.2.4, Item 12.

The normal radwaste area and engineered safeguards rooms ventilation mode is with all dampers open, Supply Fan V-10 running, one or both exhaust fans (V-14A and/or V-14B) running, and the exhaust dampers (PO-1839 and PO-1840) controlled by filter intake pressure to maintain balanced airflow from all areas. A high-activity level at the filter intake plenum will actuate the radiation monitor (RE-1809) which will close the radwaste area supply damper (PO-1809), trip one exhaust fan (V-14A or B) if both are running, close the respective exhaust damper, and trip the supply fan (V-10) which will in turn close the supply damper. The remaining exhaust fan will maintain a slight negative pressure on the radwaste area to prevent leakage out of the building. The tripped exhaust fan will restart if 2.5 inches of water vacuum is not maintained in the exhaust plenum. A high-radiation level in either of the exhaust ducts from the safeguards rooms will automatically close the supply and exhaust dampers for the affected room. Continued cooling of air within the safeguards rooms is provided by the local cooling units.

The normal ventilation mode in the fuel handling area during reactor operation or reactor shutdown is Supply Damper PO-3007 open, Supply Fan V-7 operating, one or both exhaust fans (V-8A or V-8B) operating, and one or both gravity exhaust dampers open. No change in the normal ventilation mode occurs in the unlikely event of a DBA unless the DBA is accompanied by a loss of offsite power at which time the ventilation fans will be shed from their respective bus and the dampers will close. Upon a fuel building high-radiation area alarm, Fan V-7 is manually tripped which closes Damper PO-3007 and one exhaust fan is manually tripped closing its gravity damper. The remaining running fan continues to run maintaining a slight negative pressure on the fuel building to prevent leakage from the building. Upon loss of instrument air, Supply Damper PO-3007 will shut. The supply fan and one exhaust fan will be manually tripped to ensure no building leakage in the unlikely event a simultaneous release of activity occurs within the fuel building.

9.8.5 SAFETY EVALUATION

9.8.5.1 Introduction

The Heating, Ventilation and Air Conditioning Systems covered in this section are those which were evaluated by the NRC in SEP Topic IX-5 dated February 11, 1982.

In determining which systems to evaluate under this topic, the NRC used the definition of "systems important to safety" provided in Regulatory Guide 1.105. The definition states systems important to safety are those necessary to ensure (1) the integrity of the reactor coolant pressure boundary, (2) the capability to shut down the reactor and maintain it in a safe condition, or (3) the capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposures comparable to the guidelines of 10 CFR Part 100, "Reactor Site Criteria." This definition was used to determine which systems or portions of systems were "essential." Systems or portions of systems which perform functions important to safety were considered to be essential.

9.8.5.2 Evaluation

1. Control Room Heating, Ventilation and Air Conditioning (CRHVAC) System

   The function of the CRHVAC system is to provide a controlled environment for the comfort and safety of control room personnel and to assure the operability of control room components during normal operating, anticipated operational transient and design basis accident conditions.

   This system was modified during the 1983 outage in response to NUREG-0737, Item III.D.3.4 concerns. The system is described in Subsection 9.8.2.

   A safety evaluation for this system is presented in Subsection 6.10.3, Control Room Habitability.

   Safety Analysis for dose consequences are presented in Chapter 14 for various accident conditions.

2. Spent Fuel Pool Area Ventilation System

   The function of the spent fuel pool area ventilation system is to maintain ventilation in the spent fuel pool equipment areas, to permit personnel access, and to control airborne radioactivity in the area during normal operation, anticipated operational transients and following postulated fuel handling accidents.

   Based on the fuel handling accident analysis in Section 14.19, it was determined that the system is nonessential.

3. Radwaste Area Ventilation System

   The radwaste area ventilation system services most areas within the auxiliary building during normal operation, including the engineered safeguard equipment rooms (east and west), the charging pump room, the primary drain tank pump room and the boric acid control area. These areas house equipment (Emergency Safeguards systems and the Chemical and Volume Control System) which operates either post-accident or for the safe shutdown of the Plant. During emergency conditions, East and West Safeguards Rooms have their own emergency coolers. CVCS is no longer credited for accident response. Therefore, the service conditions within the engineered safeguards equipment rooms (east and west) areas and the equipment that maintains those conditions are considered essential. The service conditions within the charging pump room and the equipment that maintains those conditions are considered important but not essential.

   If loss of instrument air were to occur, the Supply Damper PO-3010 A, B, C and D, radwaste area Supply Damper PO-1809, the two Exhaust Dampers PO-1839 and PO-1840 and safeguard rooms supply and exhaust dampers would fail closed. This would result in a loss of ventilation for the Chemical and Volume Control System. In addition, if offsite power is lost, the radwaste area ventilation system would fail.

This event actually occurred during a Plant trip which occurred on September 24, 1977 when the switchyard "R" bus was automatically de-energized during an electrical storm. The CVCS was required to operate 4 hours and 34 minutes on diesel power with the radwaste area ventilation system de-energized. No temperature-related equipment failures occurred in the auxiliary and radwaste areas. This demonstrates that ample time exists for operator action. The probability of a sustained loss of instrument air is not credible since station demand is less than 250 ft^3/min and the Plant is equipped with three 288 ft^3/min compressors, two of which can be powered from Emergency Diesel 1-1, and the other from 1-2. In addition, the feedwater purity building houses two 876 ft^3/min compressors, which can be paralleled into the original Plant instrument air system by opening a single control room activated control valve. These two compressors do require offsite electrical power.

The loss of offsite power does have a higher probability of occurrence than loss of instrument air, but loss of offsite power also trips the reactor and only activates the engineered safeguard equipment. Thus, there is a minimum of operating equipment to add heat. A simplified analysis was performed on the charging pump room assuming the three pump motors provide the heat input. The only other heat input would be that radiated from the insulated process lines carrying 120°F water. Since the normal design ambient for the pump and motor is also 120°F, the terminal temperature from this source is equal to the design temperature. This demonstrates less than an 11°F rise in 6 hours and a temperature rise of only 0.4°F during the fifth hour. Thus, assuming an initial temperature of 80°F, it would take on the order of 83 hours to reach the design temperature of 120°F. This would allow ample time to restore offsite power or to install temporary air movers.

Although the Chemical and Volume Control System, a system required for Plant safe shutdown, relies on the radwaste area ventilation system for maintaining its operational service conditions, it was demonstrated that a short loss of the radwaste area ventilation system has no adverse effect on the Chemical and Volume Control System and that adequate time exists for corrective action. Although the present radwaste area ventilation system is susceptible to single mode failure, it was found that a safety grade ventilation system is not required for this area based on the long time available for operator corrective action.

4. Turbine Building Ventilation System

   The only area in the turbine building which is considered to be essential to safety is the auxiliary feed pump room. During normal operation, air is supplied to the auxiliary feed pump room by one of the turbine building air handling units and air is exhausted back to the main turbine space via an exhaust duct located in the ceiling of the auxiliary feed pump room.

   A single duct failure or loss of offsite power would result in the loss of ventilation of this room which could potentially cause the failure of both auxiliary feed pumps to perform when required.

   However, tests were reported to the NRC in a November 1, 1982 letter which simulated loss of ventilation in the auxiliary feedwater pump room. These were conducted for both motor-driven auxiliary feedwater pump operation and steam-driven auxiliary feedwater pump operation. The tests verified that the room can safely withstand a loss of power to the ventilation units for a long period of time, at least 24 hours. In addition, a 1996 modification to the steam supply piping for P-8B provided a slight reduction in heat input to the room. Also, the simple measure of opening a door provides adequate ventilation for an indefinite period.

5. Engineered Safeguard Equipment Rooms (East and West)

   The engineered safeguard equipment rooms are located in the auxiliary building. Equipment located in these rooms is:

   HPSI Pumps

   Containment Spray Pumps

   LPSI Pumps

   Auxiliary Feed Pump (West Only, P-8C)

   Shutdown Cooling Heat Exchangers

   High-Pressure Control Air Equipment

   Related Piping, Valves, Controls, etc

Each room has one cooler with two fans, powered from diverse sources. The water source for the coolers is the Service Water System. Emergency power is supplied upon loss of offsite power. The two fans V-27C and V-27D, which service the west room, receive power from Class 1E MCC 1 (B01) and MCC 2 (B02), respectively. Fans V-27A and V-27B, which service the east room, are similarly powered from MCC-1 and MCC-2, respectively. Buses MCC-1 and MCC-2 are automatically loaded onto EDG 1-1 and EDG 1-2, respectively.

6. Electrical Equipment, Switchgear and Cable Spreading Rooms Ventilation System

The areas served and operation of this system are discussed in Subsection 9.8.2.

The cable spreading room, switchgear room and battery room are considered essential because they house the reactor protection and control system, the instrumentation for shutdown and cooldown, the emergency power (ac and dc) and control power for safe shutdown systems all of which are considered important to safety.

Ventilation tests were conducted in July and August of 1982 to investigate loss of offsite power to the ventilation fans. These were reported in a November 1, 1982 letter to the NRC.

The ventilation tests showed that certain equipment in the cable spreading room cannot withstand a loss of normal ventilation for an indefinite period of time. Upon loss of normal ventilation, the operator has sufficient time, however (up to six hours), to take action to ensure that the room's design temperature of 104°F is not exceeded. Such action consists of restarting normal cable spreading room ventilation fans V-33 and V-43, or restarting supplemental ventilation fan V-47 if the emergency mode of the control room ventilation system is not required. The other corrective measures described in Subsection 9.8.2 would also be utilized if necessary. Initiation of such action(s) would be the result of a control room annunciation when the cable spreading room temperature reaches 100°F. The cable spreading room fans V-33, V-43, and V-47 are all capable of being powered from an emergency diesel generator.

The 1C and 1D switchgear rooms are not affected by a loss of ventilation since no appreciable heat sources are contained in these rooms. The battery rooms, which are contained within the larger cable spreading room, were not tested since the battery room fans are powered from a safety-related source and, therefore, would not be vulnerable to a loss of offsite power.

7. Emergency Diesel Generator Room

There are two emergency diesel generator rooms. Ventilation to maintain suitable operating temperatures for the diesel and its associated electric control equipment within each room is provided by two separate ventilation systems and are supplied from safety-related power sources. The reliable operation of these ventilation systems is considered essential to Plant safety.

The major components of these systems are the two diesel generators (1-1 and 1-2), and two cooling fans for each generator room, V-24A, V-24B, V-24C and V-24D, respectively. An intake plenum is installed between the two fans in each room.

On the basis of extensive experience with this system involving normal periods of diesel operation for test purposes, this ventilation system has been demonstrated to be of adequate design.

8. Intake Structure Ventilation System

The intake structure ventilation system is addressed in this evaluation because it services the area where the three service water pumps are located. These pumps are considered important to safety. The system consists of seven supply fans, five wall-mounted units (V-21D-H) and two roof units (V-32A and B). These supply fans draw atmospheric air into the building. The air is then exhausted back outside through five roof-mounted exhaust fans (V-30A-E).

The intake structure ventilation system was originally sized to cool circulating water pumps in addition to the service water pumps. The existing ventilation system is now oversized for normal operation since the circulating water pumps have been removed.

In the event of a power failure, several mechanisms act to prevent any rapid heat buildup. All other heat loads within the structure are secured as the Plant is shut down, service water pipes containing cool lake water act as heat sinks, and the room is not airtight allowing some limited convective cooling to take place. If a system failure should occur, doors opening to the outside are available and should provide sufficient airflow even with multiple fan failures. Inspection of the intake structure at eight-hour intervals provides additional protection against excessive heat buildup.

9. Penetration and Fan Room Ventilation System

   The penetration and fan room ventilation system provides cooling air to the feedwater pipe penetration room, the main steam pipe penetration room and fan room. Although this ventilation system services the main steam system and component cooling water system, both considered essential for a shutdown of the Plant, it is not considered essential as defined in Subsection 9.8.5.1, because the essential equipment located in this area is being qualified to survive a main steam line break within this area.

9.9 SAMPLING SYSTEM

9.9.1 DESIGN BASIS

The sampling systems are designed to permit liquid and gaseous sampling for analysis and chemistry control of the Plant primary and secondary fluids. Samples are used to determine if chemical and radiochemical concentrations are within the prescribed operating limits.

9.9.2 SYSTEM DESCRIPTION AND OPERATION

The sampling system is a collection of smaller subsystems which are designed to sample various Plant fluids. These subsystems are designated by the Plant systems or fluid sampled. Table 9-16 lists each subsystem.

The NSSS Sampling Station is located in the auxiliary building sample room.

High-temperature, high-pressure fluid samples taken from the Primary Coolant System are first passed through a delay coil to permit decay of short-lived radioactivity and then through a cooler, pressure reducing coil, flow controller and finally an analyzer or grab sample valve. All grab samples and bomb samples are taken to the chemistry lab for analysis.

Block and bleed valves, located on the reactor coolant and LPSI pump suction sample lines, provide the opportunity to backflush these lines through the sample coolers to reduce the dose rate and potential equipment contamination. The block valve is also controlled to shut on high temperature at the sample cooler outlet.

In lieu of the Post Accident Sampling and Monitoring panel (C-103), post accident fuel damage is assessed using a PCS hot leg sample line dose rate correlation to % fuel damage. Contingency plans also exist for obtaining containment air, PCS liquid, and containment sump samples that may need to be obtained to assess the extent of an accident, long after the accident had occurred. Offsite iodine monitoring is also maintained in this circumstances.

The containment hydrogen monitoring system (Figure 9-16) consists of redundant monitors designed to continuously monitor the containment hydrogen concentration during post-accident conditions. Each monitor contains a sample pump, temperature, pressure and flow controllers, and a thermal conductivity cell. Piping from the containment to the H_2 analyzer panels are heat-traced and maintained at approximately 285°F to prevent condensation in the sample stream.

A change to 10 CFR 50.44 for combustible gas control (Reference 56) changed the classification of the containment hydrogen monitoring system to non-safety related, Regulatory Guide 1.97 Category 3.

During normal Plant operation, the system is maintained at standby conditions permitting rapid start-up.

Following initial start-up and calibration, system operation may be initiated locally at the panel or remotely from the control room. Once initiated, operation is automatic.

The Turbine Plant Analyzer Station is located in the turbine building. This station contains sample pressure reducing and cooling equipment including valves, pressure regulators, pressure indicators, flow regulators, piping grab sample sinks and continuous analyzers for various parameters such as conductivity, dissolved oxygen, sodium, hydrazine, and pH. A data acquisition system, indicators and an annunciator, to alarm abnormal conditions, are located at the Turbine Plant Analyzer Station.

At the Turbine Plant Analyzer Station, sample streams are sent through continuous analyzers. These analyzers transmit their signals to indicators for continuous display on the local analyzer panel. A data acquisition system also receives the signals from the analyzers.

The Radwaste Sample Station (Figure 9-17), located in the auxiliary building sample room, provides sample streams for grab sampling or collection in sample bombs. The sample streams are radioactive or potentially radioactive fluids.

The Radwaste Addition Sample Station, located in the new radwaste building sample room, provides sample streams for grab sampling or collection in sample bombs. The sample streams are radioactive or potentially radioactive fluids.

Table 9-17 is a summary of sample points.

9.9.3 SYSTEM EVALUATION

The sampling system obtains a maximum of information from a number of separately located sample points and stations. All of the continuous sample analysis equipment is located near its sample conditioning equipment which permits rapid detection of deteriorating conditions of either the samples or the sampling equipment.

9.10 CHEMICAL AND VOLUME CONTROL SYSTEM

9.10.1 DESIGN BASIS

The Chemical and Volume Control System (CVC), a CP Co Design Class 3 system, is designed to:

1. Maintain the required volume of water in the Primary Coolant System over the range of full to zero reactor power without requiring makeup

2. Maintain the chemistry and purity of the primary coolant

3. Maintain the desired boric acid concentration in the Primary Coolant System

4. Pressure test the Primary Coolant System

The design parameters for the Chemical and Volume Control System and components are listed in Table 9-18.

The portions of the system utilized for Primary Coolant System isolation and for Containment isolation are CPCo Class 1.

9.10.2 SYSTEM DESCRIPTION AND OPERATION

9.10.2.1 General

The Chemical and Volume Control System is shown in Figure 9-18. The letdown coolant from the cold leg of the Primary Coolant System passes through the tube side of the regenerative heat exchanger and is partially cooled. The cooled fluid is then partially depressurized as it passes through the letdown stop valves and orifices. The temperature and pressure of the letdown coolant are finally reduced to the operating requirements of the purification system by the letdown heat exchanger and back pressure valve, respectively. The coolant then passes through an ion exchanger and a filter and is sprayed into the volume control tank. The charging pumps remove the coolant from the volume control tank and return it to the Primary Coolant System by way of the shell side of the regenerative heat exchanger. The heat exchanger transfers heat from the letdown coolant to the charging coolant before the charging coolant is returned to the Primary Coolant System.

When the level in the volume control tank reaches the high level set point, the letdown flow is automatically diverted to the liquid radwaste system. When the level in the volume control tank reaches the low-level set point, makeup water, borated to the existing concentration of the Primary Coolant System, may be manually supplied to the suction of the charging pumps.

The volume control tank is designed and sized with a large enough capacity that with the level in the normal control band, the tank can accommodate a zero to full power increase or a full to zero power decrease.

The boric acid concentration and chemistry of the primary coolant are maintained by the Chemical and Volume Control System. Concentrated boric acid solution is prepared in a batching tank and is stored in two concentrated boric acid storage tanks. Two pumps are provided to transfer concentrated boric acid to a blender where the boric acid is mixed with primary makeup water in a predetermined ratio. The solution is introduced to the Primary Coolant System by the charging pumps. Boric acid can also be gravity fed directly from the concentrated boric acid storage tanks to the suction of the charging pumps.

Chemicals are introduced to the Primary Coolant System by means of a metering pump which pumps the chemical solution from a chemical addition tank and introduces it to the charging pump suction header.

Depleted zinc ions are introduced to the PCS via the Zinc Addition System for reduction of dose to personnel through the removal of radioactive cobalt ions from the inner walls of PCS piping.

The Primary Coolant System may be pressure tested for leaks by means of the variable speed charging pump. The system is also provided with connections for installing a hydrostatic test pump.

9.10.2.2 Volume Control

The CVC automatically adjusts the volume of water in the Primary Coolant System using a signal from the level instrumentation located on the pressurizer. The system reduces the amount of fluid that must be transferred between the Primary Coolant System and the CVC during power changes by employing a programmed pressurizer level set point which varies with reactor power level. The set point varies linearly with reactor power, defined for this purpose as the average primary coolant temperature measured across a steam generator. This linear relationship is shown in Figure 4-9. The control system compares the programmed level set point with the measured pressurizer water level. The resulting error signal is used to control the operation of the charging pumps and the letdown valves as described below. The pressurizer level control program is shown in Table 4-9.

The pressurizer level control program adjusts the charging rate of the variable capacity charging pump, normally in operation, to obtain a flow equal to the letdown flow through one letdown stop valve and orifice plus the total primary coolant pump seal bleedoff flow. If power changes or abnormal operations cause a large drop in the pressurizer level, one or both of the constant capacity charging pumps start to return the level to the normal control band. If conditions cause a large rise in the pressurizer level, additional letdown stop valves open to lower pressurizer level.

Since the normal letdown flow plus the primary coolant pump controlled bleedoff flow slightly exceeds the capacity of one constant capacity charging pump, one of two method of maintaining pressurizer level is used when the variable capacity charging pump is removed from service.

One method places one constant capacity charging pump in manual and allows the pressurizer level control program to cycle the second constant capacity charging pump on and off automatically to maintain level. One of the letdown orifice stop valves may be closed to reduce the cycling of the letdown orifice stop valves during this method. The second method places both constant capacity charging pumps in manual and allows the pressurizer level control program to maintain level by cycling the letdown stop valves.

The volume control tank level may be automatically controlled. When the level in the tank reaches a high-level set point, the letdown flow is automatically diverted to the liquid waste disposal system. When the level in the tank reaches the low-level set point, makeup water is manually supplied to the charging pumps. When the level in the tank reaches a low-low set point, the system automatically closes the outlet valve on the volume control tank and switches the suction of the charging pumps to the safety injection and refueling water tank.

The volume control tank can store enough coolant below its normal operating level to compensate for a full to zero power decrease in the primary coolant volume without requiring makeup. The tank is supplied with hydrogen and nitrogen gas. Gases may be vented to the waste gas surge tank.

9.10.2.3 Chemical Control

The CVC purifies and conditions the primary coolant by means of ion exchangers, filters and chemical additives.

The purification demineralizers contain a mixed bed resin which removes soluble nuclides by ion exchange and insoluble nuclides by impaction of the particles on the surface of the resin beads. A demineralizer post-filter is located downstream of the purification demineralizers to filter out resin material that may be carried over from the demineralizers. In addition, the filter may be operated as either a prefilter or a post-filter.

The primary coolant is chemically conditioned to the typical conditions shown in Table 4-16 by:

1. Hydrazine scavenging to remove oxygen during start-up

2. Maintaining excess hydrogen concentration to control oxygen concentration during operation

3. Chemical additives to control pH during operation

The chemical addition tank and metering pump are used to feed chemicals to the charging pumps which inject the additives into the Primary Coolant System. The concentration of hydrogen in the primary coolant is controlled by maintaining a hydrogen atmosphere in the volume control tank.

The chemical control system is designed to prevent the activity of the primary coolant from exceeding approximately 292 μCi/cc with failed fuel elements.

9.10.2.4 Reactivity Control

The boron concentration of the primary coolant is controlled by the CVC to:

1. Optimize the position of the control rods.

2. Compensate for reactivity changes in the temperature of the coolant, burnup of the core and variations in the concentration of xenon in the core (see Figure 9-19).

3. Provide a margin of shutdown for maintenance and refueling.

The system includes a batching tank for preparing the boric acid solution, two tanks for storing the solution and two pumps for supplying boric acid solution to the makeup system.

Normally, the system adjusts the boron concentration of the primary coolant by "feed" and "bleed." To change concentration, the makeup (feed) system supplies either water or concentrated boric acid to the charging pumps, and the letdown (bleed) stream is diverted to the waste disposal system. Toward the end of a core cycle, the quantities of waste produced due to the "feed" and "bleed" operations become excessive. Then, the deborating demineralizer is used to reduce the boron concentration.

The system adds boron to the primary coolant and thereby decreases reactivity at a sufficient rate to override the maximum increase in reactivity due to cooldown and the decay of xenon in the reactor.

The control rods can decrease reactivity far more rapidly than the boron removal system can increase reactivity. The maximum equivalent reactivity insertion rate of the rods is 143 ppm/min; whereas the maximum boron reduction rate is only 3 ppm/min.

9.10.2.5 Pressure-Leakage Test System

The Primary Coolant System can be tested for leaks while the Plant is at power by monitoring pressurizer level and charging rate. The charging pumps may also be used to hydrostatically test the primary system at design pressure when the Plant is shut down.

9.10.2.6 Component Functional Description

The major components of the Chemical and Volume Control System perform the following functions:

1. Regenerative Heat Exchanger

   The regenerative heat exchanger transfers heat from the letdown stream to the charging stream. Materials of construction are primarily austenitic stainless steel.

2. Letdown Heat Exchanger

   The letdown heat exchanger cools the letdown stream from the tube side of the regenerative heat exchanger to a temperature suitable for entry into the purification demineralizer. Component Cooling System fluid is the cooling medium on the shell side of the letdown heat exchanger, with the letdown stream passing through the tube side. Materials of construction are primarily austenitic stainless steel.

3. Purification Demineralizers

   The two purification demineralizers provide a means of removing undesired ionic species such as activation/fission products and lithium from the primary coolant system. They are configured in one of two ways:

   1) One vessel is loaded with mixed bed resin in the borate/lithium form and the other vessel loaded with cation only resin in the hydrogen form. The borate/lithium demineralizer is used during normal operation to remove ionic specie without removing lithium. The cation demineralizer is placed in service periodically to remove the natural build in of PCS lithium.

2) One vessel is loaded with mixed bed resin in the borate/lithium form and the other vessel loaded with mixed bed resin in the borate/hydrogen form. In this configuration the borate/lithium form demineralizer is used during normal operation to remove ionic specie without removing lithium. The borate/hydrogen form demineralizer is placed in service periodically to remove the natural build in of PCS lithium. During PCS source term evolutions the borate/hydrogen form demineralizer is placed in service.

Each unit is designed to handle maximum letdown flow of 120 gpm. The vessels and retention screens are constructed of austenitic stainless steel.

4. Deborating Demineralizer

The deborating demineralizer may be used to remove boron from the primary coolant when this mode of operation is preferable to a feed and bleed operation, or may be used as a purification demineralizer. The anion resin used for deborating is initially in the hydroxyl form and is converted to a borated form during boron removal. The unit is designed for the maximum letdown flow of 120 gpm, and the quantity of resin is sufficient to remove the equivalent of 50 ppm of boron from the entire Primary Coolant System. The vessel and retention screens are of austenitic stainless steel construction.

5. Purification Filters

The purification filters collect resin fines and insoluble particulates from the primary coolant. The filters will accommodate maximum letdown flow of 120 gpm. The filter housing is austenitic stainless steel.

6. Volume Control Tank

The volume control tank accumulates water from the Primary Coolant System. The tank has enough capacity to accommodate the variation in water inventory of the Primary Coolant System due to power level changes in excess of that accommodated by the pressurizer. The tank provides a gas space where hydrogen atmosphere is maintained to control the hydrogen concentration in the primary coolant. A vent to waste processing system permits removal of gaseous fission products released from solution in the volume control tank. The tank is of austenitic stainless steel construction and provided with overpressure protection. Level controls release coolant to the waste processing system on high level or notify the operator of the need to supply makeup water.

7. Charging Pumps

   Three charging pumps supply makeup water to the Primary Coolant System. The pumps return coolant to the Primary Coolant System at a rate equal to the purification flow rate and the bleedoff rate. The charging pumps automatically start upon a safety injection signal and discharge concentrated boric acid into the Primary Coolant System. P-55B and P-55C automatically start upon low pressurizer level. The pumps are of the positive displacement type. All wetted parts, except seals, are of austenitic stainless steel. Two of the pumps are fixed capacity pumps while one (P-55A) is a variable capacity pump. Any two of the three pumps are capable of providing an output of 68 gpm, with a single pump providing a minimum of 33 gpm. The normal purification flow rate is specified in Table 9-18. Accumulators are located on the suction and discharge of each pump to reduce pump induced vibrations.

8. Chemical Addition Tank

   The chemical addition tank is used to prepare chemicals for primary coolant pH control, oxygen control, and source term reduction evolutions. These chemicals are added to the suction of the charging pumps with the metering pump. The tank is austenitic stainless steel.

9. Metering Pump

   The metering pump is an air operated double diaphragm pump with wetted parts of austenitic stainless steel. The pump is used to inject a controlled amount of chemicals into the suction of the charging pumps.

10. Concentrated Boric Acid Storage Tanks

    Each of the two concentrated boric acid tanks stores enough concentrated boric acid solution to bring the reactor to a cold shutdown condition at any time during the core lifetime. The combined capacity of the tanks will also be sufficient to bring the primary coolant to refueling concentration. The tanks are heated to maintain a temperature above the saturation temperature of the concentrated solution, and sampling connections are used to verify that proper concentration is maintained. The tanks are constructed of stainless steel.

11. Boric Acid Pumps

    The two boric acid pumps supply boric acid solution at the desired concentration to the charging pumps through the blender. Upon a safety injection signal, these pumps line up with the charging pumps to permit direct introduction of concentrated boric acid into the Primary Coolant System. Each is capable of supplying boric acid at the maximum demand conditions. Each pump is capable of providing a minimum flow of 68 gpm. Wetted parts of the pumps are stainless steel.

12. Process Radiation Monitor

    The process radiation monitor monitors the fluid from the primary coolant loop for high levels of activity which would provide an indication of failed fuel.

9.10.3 OPERATIONS

9.10.3.1 Start-Up

During start-up, the reactor is brought from cold shutdown to hot standby at normal operating pressure, zero power temperature, with the reactor critical at a low power level. While the primary coolant is being heated, and until the pressurizer steam bubble is established, the charging pumps in combination with the backpressure regulating valves in the CVCS system maintain pressure in the primary system. During the heatup and after the steam bubble is established, the operator adjusts the pressurizer water level manually, with the intermediate pressure letdown control valves, the letdown orifice bypass control valves and/or the letdown orifices. The level controls of the volume control tank automatically divert the letdown flow to the waste disposal system.

If the residual activity in the core is insufficient to reduce the oxygen in the primary coolant by recombining it with excess hydrogen prior to start-up, hydrazine is used to scavenge the oxygen. If required, chemicals are added to control the pH of the coolant.

The volume control tank is initially vented to the radioactive waste treatment system. After the tank is purged with nitrogen, a hydrogen atmosphere is established and the vent is secured.

Throughout start-up, one purification filter is in service to reduce the activity of wastes entering the radioactive waste treatment system. When the Primary Coolant System reaches hot standby temperature and pressure, one or both purification ion exchangers are put into service.

Depending on limitations placed on the shutdown margin, the boric acid concentration may be reduced during heatup. The operator may inject a predetermined amount of primary makeup water by operating the system in the dilute mode. The concentration of boric acid in the primary coolant is measured by analyzing samples.

9.10.3.2 Normal Operations

Normal operation includes operating the reactor at hot standby and when it is generating power, with the Primary Coolant System at normal operating pressure and temperature.

During normal operation:

1. Level instrumentation on the pressurizer automatically controls the volume of water in the primary system by adjusting the charging rate of the variable capacity charging pump.

2. Instrumentation on the volume control tank automatically controls the level of water in the tank as described in Subsection 9.10.2.

3. The operator controls the hydrogen concentration and pH of the coolant as described in Subsection 9.10.2.3.

4. The operator may compensate for changes in the reactivity of the core by controlling the concentration of boric acid in the primary coolant. He may operate in three modes.

    a. In the dilute mode, the operator preselects a quantity of primary makeup water and introduces it into the charging pump suction at a preset rate. When the selected quantity of makeup water has been added, the flow is secured upon signal from the primary makeup water batch controller.

    b. In the borate mode, the operator preselects a quantity of concentrated boric acid and introduces it as a preset rate as described in a. above.

    c. In the blend mode, the operator presets the flow rates of the primary makeup water and concentrated boric acid for any blend between primary makeup water and concentrated boric acid. This mode is primarily used to supply makeup to the safety injection and refueling water tank.

9.10.3.3 Shutdown

Plant shutdown is a series of operations which bring the reactor plant from a hot standby condition at normal operating pressure and zero power temperature to a cold shutdown.

Before the plant is cooled down, the volume control tank is vented to the gaseous Radwaste System to reduce the activity and hydrogen concentration in the Primary Coolant System. The operator may also increase the letdown flow rate to accelerate degasification, ion exchange, and filtration of the primary coolant.

Before the plant is cooled down, the operator increases the concentration of boric acid in the primary coolant to the value required for cold shutdown. This is done to assure that the reactor has an adequate shutdown margin throughout its period of cooldown.

During cooldown, the operator uses the charging pumps to adjust and maintain the level of water in the pressurizer. The operator can introduce a calculated combination of concentrated boric acid and primary makeup water through the blender into the charging pumps' suction. The flow ratio for each addition is manually selected and provided by the blender inlet valves and controllers. The operator may switch the suction of the charging pumps to the safety injection and refueling water tank (SIRW). A portion of the charging flow may be used as an auxiliary spray to cool the pressurizer, when the pressure of the primary system is below that required to operate the primary coolant pumps.

In the event that the SIRW tank is unavailable, borated water from the Spent Fuel Pool (SFP) may be gravity fed to the charging pumps suction header. The flow path is via a fire hose connected between the discharge of the SFP Cooling System and the charging pump suction header (see Section 1.8.5).

9.10.3.4 <u>Emergency Operations</u>

Presently the CVCS is not credited in the Chapter 14 accident analyses with any mitigating actions. However, the system responds to Safety Injection Actuation Signal and the charging pumps inject concentrated boric acid into the Primary Coolant System. Either the pressurizer level control or the safety injection signal will automatically start all charging pumps, with the exception that the pressurizer level control does not start P-55A, which is assumed to be operating during normal conditions. The safety injection signal will also cause the charging pump suction to be switched from the volume control tank to the discharge of the boric acid pump. If the boric acid supply from the boric acid pump is not available, boric acid from the concentrated boric acid tanks will be gravity fed into the charging line. If the charging line inside the reactor containment building is inoperative, the line may be isolated outside the reactor containment, and the Safety Injection System may be used to inject concentrated boric acid into the Primary Coolant System.

9.10.4 DESIGN ANALYSIS

1. System Reliability

   The CVC is designed for reliability by the provision of redundant components. Redundancy is provided as follows:

Component	Redundancy
Purification Demineralizer	Parallel Standby Unit
Purification Filters	Parallel Standby Unit
Charging Pump	Two Parallel Standby Units
Letdown Flow Control	Two Parallel Standby Orifices and Valves
Boric Acid Pump and Tank	Parallel Standby Unit

The charging and boric acid pumps are powered by the diesel generators under emergency conditions. One diesel generator supplies Charging Pumps A and B and Boric Acid Pump A. The other diesel generator supplies Charging Pump C and Boric Acid Pump B. Additionally, Charging Pumps B and C can be powered from an alternate power supply (480 volt, Bus 13). Charging Pump B can be powered from the Charging Pump C power supply due to a change made in October 1989 (refer to Section 7.4 for details). Standby start features are provided so that at least one charging pump is running. The boric acid pumps and the charging pumps may be controlled locally at their switchgear.

The boric acid solution is stored in heated tanks and piped in heat-traced lines to preclude precipitation of the boric acid. Two independent heating systems are provided for the boric acid tanks and lines. Low temperature alarms and automatic temperature controls are included in the heating systems. If the boric acid pumps are not available, boric acid from the concentrated boric acid tanks may be gravity fed into the charging line. If the charging line inside the reactor containment building is inoperative, the charging pump discharge may be routed via the Safety Injection System to inject concentrated boric acid into the Primary Coolant System.

9.10.5 TESTING AND INSPECTION

The operability of the system can be demonstrated by the periodic testing of active components and the cycling of all valves. Pump and valve operability tests are conducted in accordance with the ASME OM Code.

9.10.6 REGENERATIVE HEAT EXCHANGER

The Regenerative Heat Exchanger (RHX) is CP Co Design Class 1 and was designed according to the ASME Boiler and Pressure Vessel Code, Section III, Class C (ASME B&PV Code, Section III, Class C) vessel. There are two principal reasons for this:

1. A reliable charging path was the principal reason for originally considering Class A for this component. As the detailed design of the Palisades Plant evolved, it was found desirable to add a two-inch, high-pressure line from the charging pumps through one of the high-pressure safety injection headers and to the primary loop through the four safety injection headers. Thus, an alternate charging path was available. Also, it was felt desirable to have the ability to isolate the RHX by remote manual means. Therefore, isolation valves are located on the inlet and outlet lines of both the shell and tube sides of the RHX as shown on Figure 9-18. These valves can be operated from the control room.

2. The manufacturer of the Palisades RHX was unable to obtain approval from the ASME Code "N" stamp committee to produce ASME B&PV Code, Section III, Class A components. Combustion Engineering (CE) knew of no manufacturer of such heat exchangers who had met the requirements of the "N" stamp committee. CE and the vendor agreed to additional quality control inspections, to be provided by CE, as detailed in subsequent paragraphs.

Combustion Engineering assured that the following requirements were met, which were in addition to those required for a Class C vessel, and which would normally have been performed for a Class A vessel.

1. A fatigue analysis equivalent to the requirements of a Class A vessel was performed by the manufacturer or his consultant. This analysis was reviewed under the direction of a licensed professional engineer at CE to assure its accuracy.

2. The Quality Control requirements of ASME B&PV Code, Section III, Appendix IX, 1965, W67a were met except that shop inspection personnel, although experienced in inspection techniques, did not meet in all respects the qualifications of the applicable standards. Inspections were performed in accordance with written procedures which had been reviewed by CE Quality Assurance (QA) personnel. In addition, CE QA personnel witnessed certain predetermined inspections and also conducted random periodic surveillance inspections. Inspection records were kept at the manufacturer's office and also at Combustion Engineering. Certification of inspection compliance was transmitted to Consumers Power Company.

In addition to the above, nondestructive testing was witnessed by CE QA personnel who were qualified to ASME B&PV Code, Section III, Appendix IX, 1965, W67a procedures. All nondestructive test procedures were reviewed by CE QA personnel and were deemed acceptable and in accordance with ASME B&PV Code, Section III, Appendix IX, 1965, W67a.

With the aforementioned changes in Plant design, additional analyses and quality control, we believe that Class C vessel classification of the regenerative heat exchanger was justified.

During operations the RHX primary side shell to tube-sheet welds and the primary head are periodically inspected per ASME Code requirements.

9.11 FUEL HANDLING AND STORAGE SYSTEMS

9.11.1 INTRODUCTION

The Fuel Handling System (Table 9-19) provides for the safe handling and storage of fuel under all foreseeable conditions, from receipt of unirradiated fuel at the Plant to shipment of irradiated fuel following radioactive decay. The design and construction of the system includes interlocks, travel and load limiting devices and other protective measures to minimize the possibility of mishandling or equipment malfunction that could cause damage to the fuel and potential fission product release. Power operation of the system components is supplemented by manual backup to ensure that the transfer of a fuel bundle can be completed in the event of a power failure. The fuel transfer and storage structures, the fuel handling equipment and the new fuel storage racks are CP Co Design Class 1. The high density spent fuel storage racks which replaced the existing racks and the frame supporting the fuel pool crane are Seismic Category I per USNRC Regulatory Guide 1.29.

9.11.2 NEW FUEL STORAGE

The new fuel bundles are stored in rigid racks in a dry pit next to the spent fuel cooling pool. The rack is a box-like structure consisting of 72 locations, 36 of which can hold new fuel. The other locations contain steel box beams and core plugs designed for neutron absorption in the event of a heavy mist over the pool such as that produced in fire fighting. The fuel racks can accommodate fuel assemblies having a maximum planar average U-235 enrichment of:

a. 4.05 weight percent assuming the staggered loading pattern shown in Figure 4.3-1 of Technical Specifications, which allows storage of thirty-six assemblies, or

b. 4.95 weight percent assuming the staggered loading pattern shown in Figure 4.3-1 of Technical Specifications, which allows storage of twenty-four assemblies.

The fuel racks are also used occasionally to store core plugs, poison clusters and spare control elements. During actual refueling, the new fuel bundles may be inspected and placed directly into the spent fuel pool, bypassing the new fuel storage racks.

9.11.3 SPENT FUEL STORAGE

9.11.3.1 Original Design

The spent fuel storage pool, located in the auxiliary building adjacent to the containment, is lined with stainless steel and has reinforced concrete walls and floor varying in thickness from 4-1/2 feet to 6 feet.

The original fuel racks were stainless steel with a center-to-center spacing of 11-1/4 inches. There were two 1/4-inch stainless steel plates between each pair of fuel assemblies. At design temperature, with no credit taken for soluble boron in the pool water, the maximum k_{eff} was less than 0.95. A recessed area was provided in the pool for a spent fuel shipping cask.

The spent fuel pool cooling system is conservatively designed to maintain a pool average temperature at less than 150°F with 1/3 core of fully burned up fuel in the pool, 7 days after reactor shutdown. A single failure of the cooling system would increase the pool temperature by only 3°F. The water in the spent fuel pool is borated to ≥ 1,720 ppm. The spent fuel pool cooling system is tornado protected and is located in a CPCo Design Class 1 structure, except as noted in Section 9.4.3.1.

A source for fuel pool makeup water is supplied from the Safety Injection & Refueling Water Tank (T-58), which contains borated water at a minimum concentration of 1720 ppm. Other sources include the Primary System Makeup Storage Tank (T-90) and the Recycled Boric Acid Storage Tank (T-96). Plant procedures provide additional makeup sources as well. The makeup source can be unborated water, but the amount added is controlled to prevent the pool from going below 1720 ppm.

Two fuel tilt pits are located in the fuel handling area adjacent to the spent fuel pool and connected to it by canals which are closed off by dam blocks. One tilt pit is used for normal fuel transfer activities. The second tilt pit originally was provided to accommodate an additional unit on the site, and is now utilized for spent fuel storage.

9.11.3.2 Modified Spent Fuel Storage

In 1977, due to the lack of fuel reprocessing facilities, the spent fuel pool storage capacity was increased from a capacity of 272 assemblies to a capacity of 798 assemblies. This increase in capacity was achieved by removing the existing fuel and control rod racks and replacing them with new racks with smaller center-to-center spacing.

Each individual storage location consists of two concentric 1/8-inch austenitic Type 304 stainless steel square cans with the annular space occupied by B_4C neutron absorber plates to ensure subcriticality.

A rack assembly consists of a rectangular array of storage cans with a minimum 10-1/4 inches center-to-center spacing of the fuel assemblies. The array size of each rack was chosen to optimize the use of the pool space as shown in Figure 9-20. The racks are Seismic Category I per NRC Regulatory Guide 1.29 and are restrained to the pool wall at the top and bottom of each rack to prevent excessive movement of the racks under postulated seismic accelerations. Provisions are made in the design to accommodate thermal expansion.

The second tilt pit is used for spent fuel and control rod storage and as an alternate cask laydown area. Control rods and dimensionally abnormal fuel assemblies may be stored in one rack with slightly larger cans than those used in the other racks. To minimize heat generation in the tilt pit, normally only fuel decayed for at least one year will be stored there. When fuel with a shorter decay time is stored in the tilt pit, thermal conditions are monitored to ensure that the design criteria is not exceeded.

The Nuclear Waste Policy Act of 1982 required owners of nuclear power plants to diligently pursue licensed alternatives to the use of federal storage capacity for the storage of the spent fuel expected to be generated by that plant before entering into a contract with the Federal Government to provide such storage.

A second modification to the spent fuel storage facility, in 1987, consisted of an increase of the spent fuel pool total storage capacity from 798 assemblies to 892 (see Reference 5). This increase in capacity was accomplished by removing 376 storage locations having a 10.25-inch center-to-center spacing, and replacing them with 470 storage locations having a 9.17-inch center-to-center spacing. The 9.17-inch center-to-center spacing has been accomplished by taking credit for burnup with poison. In addition, the new storage locations have more space in each location, and permit 2:1 consolidation if this method is chosen in the future to further expand storage capacity.

This second (1987) modification consisted of reracking approximately one-half of the spent fuel pool and North Tilt Pit dividing the spent fuel pool and North Tilt Pit into two regions, which are designated as Region 1 and Region 2 (see Figure 9-20). The reason only approximately one-half of the spent fuel pool was reracked was due to the need to maintain a portion of the storage capacity with larger center-to-center spacing to accommodate the storage of fuel with little or no burnup. The racks (Region 1), with 10.25 center-to-center spacing, have the required spacing to store such fuel.

The third (2013) modification to the spent fuel storage facility removed the Region 1 racks containing Carborundum® from the main Spent Fuel Pool (not the North Tilt Pit) and replaced them with Region 1 racks that contain Metamic™. Metamic™ is a patented boron carbide and aluminum metal matrix composite material that is manufactured by Holtec International and fabricated to the criteria of 10 CFR 50, Appendix B. Metamic™ is a metal matrix composite manufactured from nuclear grade boron carbide powder and aluminum powder. The Metamic™ used in the Metamic™ monitoring program using representative material coupons placed in the Spent Fuel Pool is implemented to confirm the continued integrity of the Metamic™. The Metamic™ racks have the same number of storage cells per rack as the previous Main Pool Region 1 Carborundum® racks and therefore this modification did not change the total storage capacity of the Spent Fuel Pool.

Region 1 of the Main Pool contains racks having a 10.25 inch center-to-center spacing. The Region 1 Main Pool racks contain a neutron absorbing material, The Metamic™ used in the Main Pool Region 1 racks contains a minimum B^{10} areal density of 0.02944 gm/cm^2.

Region 1 of the North Tilt Pit contains a single rack having 11.25-inch x 10.69-inch center-to-center spacing. The Region 1 North Tilt Pit rack contains a neutron absorbing material, Carborundum™, manufactured by the Carborundum Company and fabricated to the criteria of 10 CFR 50, Appendix B. Carborundum™ is a mixture of boron carbide powder and phenol formaldehyde resin in a homogeneous matrix. The Carborundum™ used in the Region 1 North Tilt Pit rack contains a nominal and minimum B_{10} areal density of 0.0959 and 0.0863 gm/cm^2, respectively. Since the long term stability of Carborundum™ neutron absorber plates has not yet been resolved, the Region 1 North Tilt Pit criticality calculations were revised to eliminate any credit taken for criticality control due to the presence of B_{10} in Carborundum™.

Region 2 contains racks in both the spent fuel pool and the north tilt pit having 9.17-inch center-to-center spacing. The Region 2 racks contain a neutron absorbing material, Boraflex, manufactured by the Brand Industrial Services, Inc, and fabricated to the Nuclear Criteria of 10 CFR 50, Appendix B. Boraflex is a silicone-based polymer containing fine particles of boron carbide in a homogeneous matrix. The Boraflex used in the Region 2 racks contains a minimum B^{10} areal density of 0.006 gm/cm^2. Since the long-term stability of Boraflex has not yet been resolved, the Region 2 criticality calculations were revised to eliminate any credit taken for criticality control due to the presence of Boraflex.

Each Region 2 rack module is provided with adjustable leveling pads which are located at selected locations within the module. The pads are remotely adjustable from above. All support pads rest directly on the pool liner and/or adapter plates.

The cask laydown area in Region 2 may contain one 11 x 11 rack which may be used to store fuel during full core off-loads. This rack may be removed to allow placement of the spent fuel shipping cask, to allow placement of equipment associated with dry fuel storage, or to allow the use of fuel inspection and repair equipment.

9.11.3.3 Structural Analysis

The spent fuel storage racks are designated Seismic Category I per NRC Regulatory Guide 1.29. Structural integrity of these racks was investigated using the loads and load combinations presented in Reference 1, which satisfy the requirements of NRC Standard Review Plan (SRP), Section 3.8.4. Stresses were computed at critical sections of the rack. A comparison of the computed versus allowable stresses indicates that the racks are structurally adequate. A discussion of this analysis, with emphasis on the seismic aspects, is found in Subsection 5.7.6.

The fuel pit and tilt pit floors and walls were analyzed to determine if they could support the fully loaded, high-density, spent fuel racks. A conservative analysis was performed for dead (fully loaded racks, hydrostatic), seismic (inertia of floors/walls, rack reactions, sloshing) and thermal loads. Forces and moments obtained at selected points were combined in accordance with the load combinations presented in Subsection 5.9.1.1.2. The maximum tensile/compressive stress was computed for each load combination and compared with the required yield strength of the structure ("Y"). For the seven walls and two floors analyzed, the minimum factor of safety was found to be 1.1 and the average factor of safety was found to be 4.5. Therefore, it was concluded that the fuel pit and tilt pit floors and walls have adequate strength to safely support the increased fuel storage.

The spent fuel pool structure was designed for ductile behavior (ie, with reinforcing steel stresses controlling the design). The acceptance criteria were stated in Chapter 5, Appendix A of the 1980 FSAR. These criteria were applied in the 1979 structural reanalysis. Acceptance is based on maintaining structural integrity and ductile behavior of the pool structure.

The fuel racks (Region 2) were analyzed for normal and faulted load combinations in accordance with the NRC "OT Position for Review and Acceptance of Spent Fuel Storage and Handling Applications." The results of this seismic and structural analysis show that the Region 2 racks meet all structural acceptance criteria adequately.

An analysis was performed to demonstrate that the Region 2 rack can withstand a maximum uplift load of 4,000 pounds. This load can be applied to a postulated stuck fuel assembly without violating the criticality acceptance criterion. Resulting stresses are within acceptable stress limits, and there are no changes in rack geometry of a magnitude which cause the criticality acceptance criterion to be violated.

The unlikely event of dropping a fuel assembly has also been addressed. Both the Region 1 and Region 2 racks are designed to absorb the impact of a dropped assembly without experiencing significant deformation. In the unlikely event that a fuel assembly is dropped onto one of the racks the assembly would end up sitting on the top of the racks separated from the active fuel column of the assemblies in the storage rack by greater than 10 inches of borated water. This separation is adequate to preclude neutron interaction. Therefore, the reactivity increases due to the dropped assembly scenario for the Region 1 and Region 2 racks is bounded by the misloaded assembly accident.

Consistent with the criteria of the NRC "OT Position for Review and Acceptance of Spent Fuel Storage and Handling Applications," the racks were evaluated for overturning and sliding displacement due to earthquake conditions under the various conditions of full, partially filled, and empty fuel assembly loadings. The fuel rack nonlinear time history analysis shows that the fuel rack slides a minimal distance. This distance combined with the rack structural deflection and thermal growth is less than rack-to-rack or rack-to-wall clearances at all locations, except at the interface between the Region 1 Metamic™ (Main Pool) and Region 2 racks. At this interface, the Region 1 Metamic™ rack baseplates extend beyond the perimeter envelope of the cell region in order to protect the rack cellular structure from impact during a seismic event and maintain the installed inter-rack spacing. Therefore, by design the racks are predisposed to impact each other at the baseplate level during a seismic event, rather than at the top of rack elevation. The impact stress on the rack baseplates is well below the Level A bearing stress limit per ASME Subsection NF. The factor of safety against overturning is well within the values permitted by Section 3.8.5.11.5 of the Standard Review Plan.

9.11.3.4 <u>Prevention of Criticality During Transfer and Storage</u>

The Region 1 Carborundum® racks in the North Tilt Pit are designed with B_4C plates around each assembly. Borated water surrounds the racks in the same concentration and to a level common to the refueling cavity and pool. As discussed earlier, the most recent criticality analysis for Region 1 Carborundum® racks did not take credit for B^{10} in the Carborundum®. The elimination of B^{10} in Carborundum® from the calculation is offset by crediting the soluble boron in the Spent Fuel Pool water, selective loading of the fuel interspersed with empty cells, and restricting the assembly planar average enrichment.

The Region 1 Metamic™ racks in the main pool are designed with Metamic™ as a neutron poison. Borated water surrounds the racks in the same concentration and to a level common to the refueling cavity and pool. The most recent criticality calculation for the Region 1 Metamic™ racks takes credit for B^{10} in Metamic™.

The Region 2 racks are designed for a 9.17 inch center-to-center spacing with Boraflex sheets used as a neutron absorbing material to compensate for the closer spacing. As discussed earlier the most recent criticality calculation for Region 2 did not take credit for Boraflex. The omission of Boraflex from the calculation is compensated for by taking credit for the presence of soluble boron in the spent fuel pool water and the radioactive decay time of the spent fuel being stored.

The precedent of crediting soluble boron to provide criticality control aside from normal reactor operations has already been established. Soluble boron credit was used in the “Westinghouse Spent Fuel Rack Criticality Analysis Methodology” described in WCAP-14416-NP-A. That methodology was accepted for use by an NRC Safety Evaluation dated October 25, 1996. Additional guidance outlining the requirements for use of soluble boron has been issued by the NRC and documented in “Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at Light-Water Reactor Power Plants,” Laurence I. Kopp, U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Reactor Systems Branch, February 1998.

The Region 1 and 2 criticality calculations take credit for soluble boron in the Spent Fuel Pool. Region 1 Carborundum® (North Tilt Pit) and Region 2 criticality calculations define a storage configuration but do not take credit for the solid B^{10} in the racks. Region 1 Metamic™ (Main Pool) criticality calculations do take credit for solid B^{10} in the Metamic™ material. The soluble boron credit is used to offset the various uncertainties related to the criticality calculation. The uncertainties included are for reactivity equivalencing methodology, manufacturing tolerances, and off-normal conditions that include stuck assemblies, rack deformation and complete voiding of water outside of the fuel assembly envelope in Region 1. Crediting soluble boron provides subcritical margin such that the Spent Fuel Pool k_{eff} is maintained less than or equal to 0.95.

The Region 1 Metamic™ (Main Pool) criticality calculation demonstrates that k_{eff} is less than 1.0 for the maximum enrichment with no restrictions on loading patterns. The Region 1 Carborundum® (North Tilt Pit) criticality calculation demonstrates that k_{eff} is less than 1.0 for the combination of maximum nominal planar average U-235 enrichment, burnup and restricted loading patterns defined in Section 4.3.1.1, and as augmented by Table 3.7.16-4 and Table 3.7.16-5 of the Technical Specifications, with no credit for solid boron in the racks. Similarly, the Region 2 calculation shows that k_{eff} is less than 1.0 for the combinations of maximum nominal planar average U-235 enrichment, burnup and decay time shown in Table 3.7.16-1 of the Technical Specifications with no credit for solid boron in the racks. The presence of 850 ppm of soluble boron ensures that the 95/95 k_{eff} is less than or equal to 0.95 under normal storage conditions. Considering that the Technical Specifications require the normal fuel pool boron concentration to be at least 1720 ppm, an 870 ppm margin to the 0.95 limit is inherently present for the soluble deboration event.

The results of the criticality analyses are based on worst case situations, considering fuel assemblies with the maximum fuel enrichment and minimum neutron absorber loading for Region 1 Metamic™ (Main Pool) and the maximum variations in the position of fuel assemblies within the Region 1 Carborundum® (North Tilt Pit) and Region 2 storage racks. It also considered variations in can dimensions, the most reactive temperature, calculation uncertainties, and worst case accidents for all racks. The results show that the 95/95 k_{eff} is less than or equal to 0.95 for Region 1 and for Region 2 with credit for 850 ppm and 1350 ppm of soluble boron in the fuel pool water for the deboration event and the fuel misload event, respectively (References 45 and 75).

In order to maintain a k-effective less than or equal to 0.95 for the tilt machine and fuel elevator, 850 ppm boron is required. This is maintained by meeting normal requirements outlined in Technical Specification LCO 3.7.15 and associated procedures. Credit is taken for boron to maintain k-effective less than or equal to 0.95 with a margin of 870 ppm being available due to the Technical Specification requirement of 1720 ppm.

The criticality analysis performed to support crediting soluble boron in the spent fuel pool (SFP) determined that a minimum boron concentration of 850 ppm would provide a k-effective of less than or equal to 0.95. In order to ensure that the design-basis k-effective of 0.95 is not exceeded due to potential dilution events, a boron dilution analysis to support this criticality analysis was also performed (Reference 10). As a result, it was established that a boron concentration of greater than or equal to 1720 ppm provides adequate margin for fuel assembly storage and movement within the SFP.

Based on the creditable dilution events evaluated, the 1 ½ inch fire hose station is the only system with practically an infinite water storage source (Lake Michigan) that could provide the necessary volume of water needed to dilute the SFP to 850 ppm. However, with this fire hose, it would take over 9 hours to dilute the SFP soluble boron concentration from 1720 ppm to 850 ppm. Thus, if an SFP dilution were to occur from this system, reasonable assurance exists that is would be identified and suppressed by an operator before the 0.95 k-effective limit is reached. As an additional measure, a fuel pool high level alarm was added to give an earlier warning of fuel pool increases which could lead to dilution of the soluble boron concentration.

The dilution analysis concluded that an unplanned or inadvertent event that would dilute the SFP is not credible for Palisades. Sufficient time is available to detect and suppress the worst dilution event that can occur from the minimum TS boron concentration to the boron concentration required to maintain the 0.95 k-effective design-basis limit.

9.11.3.5 Radiological Considerations

9.11.3.5.1 Radiation Shielding

Personnel performing refueling or fuel inspection activities are protected from excessive radiation levels by water shielding. Fuel assemblies are maintained under at least 10 feet of water, and individual fuel rods are maintained under at least 8 feet of water. The new fuel elevator is designed and operated such that it is not possible to lift irradiated fuel above 10’ submergence limit. This is accomplished with limit switches, a key lock and a control system (joystick and operator action). The keys are administratively controlled such that they will not be issued when irradiated fuel is stored in the new fuel elevator. Mechanical stops are provided for the remaining fuel handling equipment in order to ensure the minimum water shield thickness limits are not violated. The water level limits serve to maintain the low level of radiation required for unrestricted occupancy. Checklists require proper water level to be verified prior to moving fuel. In addition, annunciation is provided to warn operators of low water level.

9.11.3.5.2 Pool Surface Dose

The additional spent fuel assemblies in the pool will result in an increase in dose rates in the spent fuel pool area due to a buildup of radionuclides in the pool water. To determine the amount of increase, a calculational model was devised that considered the presence of activated corrosion products, leakage of the isotopes from the fuel to the pool, the decontamination factor and flow rate of the pool purification system, the isotopic half-lives and the decay time of the fuel. Using this model, the pool's activity was predicted for the original pool capacity (272 assemblies) and for the increased capacity (798 original rerack assemblies). On the refueling platform, 5 feet above the center of the pool, the dose rate increased from 2.17 mrem/h for 272 assemblies to 3.24 mrem/h for 798 assemblies. (At poolside, 1 foot from the pool wall and 5 feet above the surface, the dose rate increased from 1.58 mrem/h to 2.34 mrem/h.) The increase in the pool capacity has a negligible effect on personnel exposure. Assuming an occupancy time of 504 man-hours per year at the refueling platform and 1,134 man-year poolside for refueling operations, and an additional 52 man-hours per year poolside for routine operations, the total incremental dose due to the expansion of pool capacity from 272 to 798 assemblies is 1.43 manrem per year.

The dose rate directly above the spent fuel pool has been measured during routine area surveys on the service platform. Survey sheets were examined for the periods of time between 1975 and 1983 when the Plant was operating. Thirteen surveys contained dose rate measurements which were taken directly above the spent fuel pool. These measurements ranged from 0.2 to 3.5 millirem per hour. The average dose rate was 1.5 millirem per hour. Thermoluminescent Dosimeters (TLDs) have monitored dose adjacent (west wall) to the spent fuel pool since the beginning of plant operations. TLD results since the 1996 Refout are 0.16 millirem per hour, 0.35 millirem per hour, and 0.27 millirem per hour for the 1st, 2nd and 3rd quarters of 1997, respectively. Neither the direct surveys nor the full time dose monitoring indicate any correlation between the dose rates and the number of fuel bundles in the spent fuel pool.

9.11.3.5.3 Airborne Doses

The water evaporation rate, and hence tritium release to the environment around the spent fuel pool, is expected to change as a result of the following factors:

1. Lower calculated water temperatures for the updated FSAR in the spent fuel pool than those evaluated previously in the 1980 FSAR.

2. Higher water temperatures in the north tilt pit area relative to the main pool.

3. Increased water surface area due to utilization of the north tilt pit.

Calculations show that the overall evaporation rate will increase approximately 9%.

Airborne samples are taken in the spent fuel pool area and analyzed for tritium. Results are typically less than 0.3 DAC (see 10CFR20 for DAC definition), but may vary somewhat. As with other parameters examined, no correlation could be established between the airborne sample results and the number of fuel bundles in the spent fuel pool.

9.11.3.5.4 General Area Doses

The adequacy of the spent fuel pool and tilt pit shielding was analyzed with the QAD and ANISN computer codes, to take into account storage of additional spent fuel.

Analyses have shown that the existing shielding is generally adequate to reduce effectively neutron and secondary gamma radiation in all expected areas of occupancy surrounding the pool. However, three areas in which fission product gamma dose rates have exceeded the FSAR radiation zoning criteria (Section 11.6) have been identified. These are (1) outside the north wall of the north tilt pit, (2) outside the north wall of the existing spent fuel pool, and (3) in the space directly below the spent fuel pool cask loading area.

When the north tilt pit is used to store fuel which has decayed for at least one year, it has been calculated that the expected gamma dose rate on the north wall of the tilt pit, which is 2 feet thick, will be approximately 14 rem/h. Studies show that approximately 7 inches of lead equivalent will be required in addition to the 2-foot-thick concrete wall to achieve dose rates consistent with the FSAR radiation zoning criteria. Assuming that the spent fuel pool will be used to store fuel which has decayed for at least 36 hours, it has been calculated that the expected gamma dose rate on the north wall of the pool will exceed 10 mrem/h. Assuming the cask loading area will be used to store fuel which has decayed for at least 36 hours, it has been calculated that the gamma dose rate under the pool floor adjacent to the cask loading area will exceed 200 mrem/h.

9.11.3.5.5 Protection Against Radioactivity Release

Protection against accidental radiation release from irradiated fuel is provided by the containment ventilation system and isolation capability, if required, of the spent fuel pit and auxiliary building ventilation system. Because of the submergence of a bundle in 10 feet of water and an individual rod in 8 feet of water, any released fission products will be diluted and partially retained by the pool water.

The ventilation air for both the containment and spent fuel pool atmospheres flows through absolute particulate filters before discharging to the Plant stack. The containment is normally isolated with purge air only when access to the air room is desired. In the event that the stack discharge should indicate a release in excess of the limits in the Offsite Dose Calculation Manual , an alarm is received in the control room and the ventilation flow path from containment is closed manually from the control room. The ventilation flow paths from the fuel handling area and radwaste area are also manually closed from the control room. During refueling operations, refueling radiation monitors must be in operation and occurrence of a high radiation condition will initiate a CHR signal and close containment isolation valves.

During normal operation, the spent fuel pool area exhaust air is pulled through a prefilter and a high-efficiency filter with a particulate efficiency of 99.97% of 0.3 micron particles. The fuel building exhaust fans discharge to the main exhaust fan inlet plenum for ultimate discharge through the ventilation stack.

In the event of a fuel handling / cask (heavy load) drop accident in the spent fuel pool, the exhaust airflow is reduced to one-half by tripping the supply fan and closing the inlet damper and tripping one of the 50% capacity exhaust fans. The exhaust air flows through the high-efficiency particulate filter and a charcoal filter. See Sections 14.11 and 14.19 for specific assumptions of the Fuel Handling Building HVAC used in the safety analysis.

The radiological filter is in a bypass around the normal service filters and designed for a capacity of 10,000 ft^3/min and will retain 1,200 grams of methyl iodide. Its particulate efficiency is 99.0% for particles of 0.3 micron in size, and the filter medium has a test-proven efficiency for removal of radioactive iodine and iodine compounds as follows:

Radioactive Iodine I_2^{131}	99.0%
Radioactive Methyl Iodide $CH_3I_2^{131}$	94.0%

9.11.4 FUEL HANDLING SYSTEM

9.11.4.1 General

Refueling is accomplished by handling fuel bundles underwater at all times. The refueling cavity and spent fuel pool are filled with borated water to a common level during refueling. The use of borated water provides a transparent radiation shield, a cooling medium and a neutron absorber to prevent inadvertent criticality.

The Fuel Handling System transfers the fuel bundles between the refueling cavity and the fuel storage pool through a transfer tube. The refueling machine removes a spent fuel bundle from the core, transports it to the tilt machine and deposits it in the transfer carriage within the tilt machine. The carriage is then rotated from a vertical position to a horizontal position and moved through the transfer tube to the spent fuel storage area. The carriage is then rotated to a vertical position, the spent fuel removed and placed in a storage rack by the service platform. The service platform is also used to remove the fuel from the storage rack and deposit it in the shipping cask for shipment off the site or to deposit it in the Multi-Assembly Storage Basket (MSB) for storage at the Independent Spent Fuel Storage Installation. During all handling operations, a sufficient water shield is maintained over the top of the fuel bundle to restrict radiation exposure to operating personnel. The refueling water boron concentration is checked periodically to assure adequate shutdown margins. Water boron concentration is also checked prior to and during MSB fuel loading.

New fuel bundles are stored dry in the new fuel storage area. This area is provided with vertical racks to hold 36 replacement bundles. New fuel bundles are transported from the storage rack to the new fuel elevator by means of the fuel building overhead crane. The new fuel elevator receives the fuel bundle in its raised position and then travels to the bottom of the fuel pool. Then the fuel bundle will be picked up by the service platform for transportation to one of the designated storage spaces in the storage rack. During refueling the service platform transports the fuel bundle to the transfer carriage. Reference FSAR Chapter 1 Figures 1-4, 1-8 and 1-10 for plant layouts related to refueling equipment.

The new fuel elevator contains an inspection position to allow examination of irradiated fuel. Fuel repairs can be conducted in the elevator. The elevator is also used to transfer neutron sources between fuel assemblies.

9.11.4.2 Fuel Handling Structures

The refueling cavity is a reinforced concrete structure lined with stainless steel that forms a pool above the reactor. During the refueling, the cavity is filled with borated water to a depth which limits the radiation at the surface of the water to 2.5 mrem/h.

To prevent leakage of refueling water from the cavity, the flange of the reactor vessel is temporarily sealed to the bottom of the refueling cavity. This seal is installed after reactor cooldown but prior to the removal of the reactor vessel head and the flooding of the refueling cavity.

The refueling cavity also provides storage space for the upper guide structure, irradiated incore instrumentation, miscellaneous refueling tools and the core support barrel when its removal is required. The reactor vessel head and missile shield are stored on the operating floor.

9.11.4.3 Major Fuel Handling Equipment

1. Reactor Vessel Head Lifting Device

   The head lifting device is composed of a removable spreader bar assembly and a three-part column assembly and the rigging necessary to lift and move the head to the storage area. The column assembly which remains attached to the head also provides a working platform for personnel during maintenance, and supports the three hoists which are provided for handling the hydraulic stud tensioners, the studs, washers and nuts.

2. Upper Guide Structure Lifting Device

   When installed, this device allows the main crane to lift the upper guide structure. Three bolts are threaded into the flange of the upper guide structure using a manually operated tool. Bushings on the lifting device engage the guide studs installed on the reactor vessel flange to provide guidance during removal and insertion of the guide structure. Work platforms are provided for operating personnel and brackets are attached to the lifting device for the storage of withdrawn incore instrumentation.

3. Refueling Machine

The refueling machine is a traveling bridge and trolley which spans the refueling cavity and moves on rails located on the working floor of the containment area. The bridge and trolley motions allow coordinate location of the fuel handling hoist and guide assembly over the fuel in the core. The hoist assembly contains a coupling device which when rotated by the actuator mechanism engages the fuel bundle or control rod to be removed. The hoist assembly is moved in a vertical direction by a cable that is attached to the top of the hoist assembly and runs over a sheave on the hoist cable support to the drum of the hoist winch. After the fuel bundle is raised into the hoist and the hoist into the refueling machine mast, the refueling machine transports the fuel bundle to its new location. The capability to perform In-Mast Sipping of fuel bundles was installed in the Refueling Machine for enhanced detection of fuel defects, in 1996. Horizontal seismic motion is restrained by the bridge and trolley flanged wheels. Vertical seismic upward motion is restrained by uplifters on both the bridge and trolley of both the containment and fuel pool cranes.

The controls for the refueling machine are mounted on a console which is located on the refueling machine trolley. Coordinate location of the bridge and trolley is indicated at the console by digital readout devices which are driven by encoders coupled to the guide rails through rack and pinion gears. A system of pointer and scales is provided as a backup for the remote positioning readout equipment, and manually operated handwheels are provided for bridge, trolley and winch motions in the event of a power loss.

During withdrawal or insertion of a fuel assembly, the load on the hoist cable is monitored at the control console to ensure that movement is not being restricted. Variations from normal loads in excess of hoist load setpoints will stop the motion of the hoist winch mechanism. A zoned mechanical interlock is provided which prevents opening of the fuel grapple and protects against inadvertent dropping of the fuel. A spreader device is provided which spreads adjacent fuel bundles to provide unrestricted removal and insertion. This spreader is part of the mast assembly and is piston-operated after grappling of the fuel bundle. Safety features of the refueling machine are as follows:

a. An anticollision device on the refueling machine mast which will stop bridge and trolley motion. This device consists of a hoop and limit switches to protect the mast from hitting vessel studs, guide structures or walls of refueling cavity.

b. Interlocks which restrict simultaneous operation of either the bridge and trolley or the hoist winch drive mechanism.

c. An interlock which prevents bridge and trolley motion with spreader device actuated.

d. An override switch which must be actuated after fuel hoist operation to allow bridge or trolley motion.

e. Overload and underload switches which stop fuel hoist motion.

f. Bridge and trolley speed restriction zones over the reactor core.

g. Fuel hoist speed restriction while fuel bundle is within the core.

h. An interlock which prevents positioning of refueling machine over the tilting machine unless the tilting machine is in the vertical position.

4. Tilting Machines

Two tilting machines are provided, one in the containment building and the other in the fuel building. The tilting machine installed in the containment building consists of a fabricated hollow rectangular structure, supported through a pivot to a triangular-shaped support base. This structure is closed at one end and open at the other, which allows the transfer carriage to move completely into the structure by riding on the rails attached to the inner sides. Hydraulic cylinders attached to both the box and the frame are provided to rotate the transfer carriage to a vertical position and then to a horizontal position, as required by the fuel bundle transfer procedure. Slots are cut in the top and bottom surfaces of the box to accommodate the transfer carriage drive cables during the tilting operation.

The tilting machine installed in the fuel storage area is essentially as described above except that the box structure is open at both ends to allow the insertion and transfer of the fuel assemblies. A track is, therefore, provided to mate with the end rollers of the transfer carriage to support the weight of the transfer carriage and the fuel assemblies during the tilting operations.

Interlocks are provided to ensure the safe operation of this equipment by (1) prohibiting the lowering of a fuel bundle unless the transfer carriage has been correctly positioned in the tilting machine, (2) preventing inadvertent rotation of the tilting mechanism while a fuel bundle is being lowered, and (3) deactivating the cable drive so that a premature attempt to move the transfer carriage through the refueling tube cannot be initiated.

5. <u>Transfer Carriage</u>

A transfer carriage is provided to transport the fuel bundles from the refueling cavity through the transfer tube to the spent fuel storage area. Two main structural members form the sides of the carrier from which are supported two fuel assembly cavities and the associated bracing. The carrier rolls on rails through the transfer tube. Stainless steel wire cables connect the carrier to a drive assembly which provides the motive force. The location of the cable connections is such that during the tilting operations, a minimum of cable slack will be encountered and this slack will be automatically taken up when the vertical or horizontal stop positions are reached. Rollers on one end transfer the load of the carrier and fuel assembly to the track of the tilting machine in the fuel storage area.

The carriage has been provided with two fuel bundle locations to minimize the time required for one complete fuel transfer cycle. After the transfer carriage containing a new fuel bundle is moved into the containment area and is tilted to the vertical position, the refueling machine can deposit a spent fuel bundle into one location and remove the new bundle from the other, thus allowing parallel operation of each piece of equipment. The fuel positions in the transfer carriage are located to allow the refueling machine to move from one position to the other by utilizing only bridge motion.

6. <u>Transfer Rails</u>

This is an assembly which contains the rails on which the transfer carriage rides when moving between the refueling cavity and fuel storage area. The rail supports seat on and are welded to the ID of the 36-inch diameter transfer tube and a groove is provided to mate with the key affixed to the supports which keep the rails aligned. The rail assemblies are fabricated to a length which will allow them to be lowered for installation in the transfer tube. A gap is left in the track at the 36-inch diameter valve on the fuel storage side of the transfer tube to allow closing of the valve.

7. <u>Communications</u>

Direct audible communication between the control room and the refueling machine operator is available whenever changes in core geometry are taking place.

This provision allows the control room operator to inform the refueling machine operator of any impending unsafe condition detected from the main control board indicators during fuel movement.

8. Fuel Building Crane

In 2003, Facility Change FC-976 modified the main hoist of the Fuel Building Crane to increase the capacity of 110-tons, and to meet single failure criteria in accordance with NUREG-0612, “Control of Heavy Loads at Nuclear Power Plants,” and NUREG-0554, “Single-Failure-Proof Cranes for Nuclear Power Plants.” The Fuel Building Crane, L-3, is an indoor electric overhead traveling bridge, single trolley crane, with a radio controlled operator unit. Table 9-20 describes specifics of the Fuel Building Crane. On June 16, 2004, the NRC issued Amendment 215 to the Palisades Operating Licensee No DPR-20 to approve the use of the Fuel Building Crane as a single-failure-proof crane for below-the-hook loads up to 110 tons.

The Fuel Building Crane main hoist is used to handle spent fuel casks. The spent fuel casks are described in Sections 9.11.5 and 14.11. Prior to the upgrade of the Fuel Building Crane to single failure criteria, movement of Pacific Sierra Nuclear VSC-24 system casks was performed under site-specific heavy load requirements that conform to the recommended guidelines of NUREG-0612 and Generic Letter 85-11. The Fuel Building Crane may be operated in a non-single failure proof manner following site-specific heavy load requirements. Section 14.11 described postulated cask drop accidents.

The 15-ton auxiliary hoist of the Fuel Building Crane is not single failure proof. Postulated load drops from the auxiliary hoist have been evaluated in accordance with NUREG-0612 and are bounded by the cask drop accidents in Chapter 14.11.

When the main hoist of the Fuel Building Crane is used for single failure proof lifts or lifts in excess of 100-tons, the Auxiliary Building steel frame structure over the Spent Fuel Pool is only qualified for a maximum wind velocity of 90 mi/hr as noted in FSAR Section 5.3.1.2 and Amendment 215.

Codes and Standards

The crane was designed, constructed and erected in accordance with the requirements of:

a. Crane Manufacturing Association of America Specification #70 – Class A

b. American Welding Society Standard Specifications

c. National Electric Manufacturers Association

d. American Standards Association

e. National Electrical Code

f. National Fire Protection Association

g. ASME B30.2 – Overhead and Gantry Cranes

Factors of Safety

The following minimum factors of safety, under static full rated load stresses and based on ultimate strength of material were provided:

Material	Factor of Safety
Cast Iron	12
Cast Steel	8
Structural Steel	5
Forged Steel	5
Cables	5
Weld	5
	(Based on ultimate strength of metal in weld)
Stainless Steel	5

Note: Non-redundant parts of the lifting system (eg, the main hook) have a safety factor of 10.

Explicitly, the factors of safety are:

a. For hooks, shear blocks, bridge and trolley drives, complete hoisting mechanism, trolley frames and structural steel parts, not including bridge girders, not less than 5 for the auxiliary hoist and not less than 10 for the main hoist and lower block.

b. Bridge girders - Within the allowable stress requirements of NUREG-0554 and AISC.

c. Welds - Within the allowable stress requirements of NUREG-0554 and AISC.

d. Rope - Not less than 5 for the auxiliary hoist and 7 for the main hoist.

Mechanical Stress Analysis

In addition to the usual design requirements given in the referenced codes, the equipment is designed to meet seismic requirements as stated below.

The stresses resulting from the following seismic loads combined with normal operating stresses in no case exceed the yield point of the component materials. The seismic load was calculated as 60% of the dead load applied in any horizontal direction and 15% of the dead load applied in either direction vertically. The criteria is only applied to the unloaded crane.

Positive means are provided to prevent the crane bridge, trolley or any other items normally held by gravity from becoming dislodged and falling on equipment or structures situated below the crane.

Brakes

The main hoist is equipped with a mechanical holding brake with a minimum torque rating of 125% of the full load hoisting torque at the point of application. An emergency band brake on the main hoist drum is designed with a minimum capacity of 125% of that required to hold the design rated load. The main and auxiliary hoists are controlled by a Flux Vector Drive systems which control the motor such that lowering and hoisting speeds can be maintained at low speeds for extended periods of time. The Flux Vector Drive is equipped with a dynamic brake which diverts excess current during lowering of the hoist with a load on the hook.

The auxiliary hoist is equipped with a mechanical brake with a minimum torque rating of 125% of the full load hoisting torque.

The bridge and trolley are provided with braking resistors for normal control breaking. The brakes have torque capabilities to stop motion within 10% of rated load speed when traveling at rated speed with rated loads. Parking brakes are provided but are only actuated once the trolley or bridge comes to a complete stop or during emergency breaking.

All brakes are equally effective in both directions.

Two Blocking

Two blocking occurs when block and tackle meet.

Two blocking of main hoist could result, with full-rated load on hook, if both upper limit switches fail while hoist control is in the hoist position. Failure of both upper limit switches is not considered to be credible. An energy absorbing torque limiter within the main hoist reducer assembly will further protect the hoist system by limiting the load on the hoisting system.

The main hoist motor is rated at 25 hp, 900 r/min, with 3-step control in either direction. The main hoist holding brake will not prevent two blocking of the hoist under rated load conditions.

Two blocking of auxiliary hoist could result with full-rated load on hook, if upper limit switch fails while hoist control is in the hoist position.

The auxiliary hoist motor is rated at 25 hp, 900 r/min, with stepless control in either direction. The auxiliary hoist holding brake will not prevent two blocking of the hoist under rated load conditions.

Hoist Drive System

For the 110-ton hoist, the hoist drive is driven by a 1,020:1 ratio gearbox.

Hoisting machinery consists of a continuous duty, telemotive drive, Class H insulation Marathon motor which drives through necessary gear reductions to a winding drum. Gears in reduction units are mounted on short shafts and supported between bearings. The drum gear is pressed on and keyed to the winding drum. The hoist motor is coupled to the speed reducer.

The hoist drum is mounted on pedestal bearings supported on a trolley truck assembly.

The hoist drive motor and gearbox are attached to the trolley truck.

An essentially identical arrangement exists for the 15-ton auxiliary hoist drive system.

Limit Switches

The main hoist has control circuit screw-type upper and lower limit switches and a redundant block-operated, paddle-type upper limit switch. These limit switches serve to interrupt current to the motor when the hoist block reaches or exceeds a predetermined limit of travel, thus setting brakes. The former limit switch is reset automatically by moving controller to opposite direction. The latter limit switch is reset using the key bypass switch.

The auxiliary hoist has control circuit upper and lower limit switches capable of setting its brake.

Automatic reset-type limit switches of the forked lever type have been provided to limit travel of bridge on each end of the frame runway. The limit switch is reset by reversal of bridge direction of travel.

An equivalent arrangement to that discussed for the bridge has been provided to limit trolley travel at each end.

Finally, limit switches have been provided to prevent traversal of the fuel pool. Under fuel transfer cask handling operations, the limit switches may be bypassed by a key kept under strict administrative control to allow placing cask in loading area of pool.

Controls

Control of all crane functions is from a radio controlled station carried by the crane operator.

The radio controlled station weighs about 7 pounds and has a master key lock power (on-off) switch with additional key lock switches for fuel pool and cask laydown overrides.

The radio control station is housed in a NEMA I enclosure with four-dead man style, spring-return, detent rotary switches for speed control. The master main (on-off) switch is a heavy duty, toggle-type with a mechanical latch required for the on position.

The bridge and trolley drive controllers are three speed, full magnetic with protection, furnished with NEMA I steel enclosures, NEMA Class 162 unbreakable resistors, general duty master switches, and are mounted on the crane for ease of maintenance and convenience. They are standard GE Type IC 7427A reversing-plugging controllers. Movement of master switch to first point closes the correct directional contactor to place all starting resistance in the circuit. Accelerating points are controlled by automatic relays which cut out resistance until full speed is attained. Quick reversal of master switch results in immediate reversal of directional contactors but acceleration contactors are held open by plugging relay until motor has stopped and reversed. Some braking is accomplished by plugging motor; however, controlled stopping is accomplished through holding brakes.

The main and auxiliary hoist drive controls are Flux Vector Drive computer controllers mounted in an existing NEMA 1 enclosure.

Electrical

The electrical systems furnished are 3 phase, 3 wire, 60 hertz, 460 volt, ac power. Power is provided through the main disconnect switch located on the crane to all motors, drives and controls. There is an additional fusible disconnect switch located on the spent fuel floor to control the power to the crane.

A main line contactor is provided and is operated by stop and reset buttons located conveniently for the operator. A control circuit transformer with fuses provides 110 volt control power to all control panels on the crane with the exception of the main and auxiliary hoist motor Flux Vector Drive systems. Low voltage protection is included. Overload protection for the motors is included on the individual motor control panels at 125% overcurrent, with the exception of the main and auxiliary hoist motors which are controlled by the Flux Vector Drive computer controls.

The wire sizes are suitable for crane rated motors in accordance with the National Electrical Code. All insulation, conduit and fittings conform to the requirements of the National Electrical Code.

9. Spent Fuel Cask Lifting Device

When the shipment of spent fuel is feasible, a special spent fuel cask lifting device shall be used. This device shall conform to the standards of ANSI N14.6-1986 or 1978 and the recommendations of NUREG-0612.

10. Spent Fuel Handling Machine (SFHM)

The spent fuel handling machine, also referred to as the service platform, is a traveling bridge and trolley which spans the spent fuel pool and moves on rails located on the working floor of the spent fuel pool area. The bridge and trolley motions allow coordinate location of the fuel handling hoist and guide assembly over the fuel in the spent fuel pool. The hoist assembly contains a coupling device which when rotated by the actuator mechanism engages the fuel bundle or control rod to be removed. The hoist assembly is moved in a vertical direction by a cable that is attached to the top of the hoist assembly and runs over a sheave on the hoist cable support to the drum of the hoist winch. After the fuel bundle is raised into the mast the spent fuel handling machine transports the fuel bundle to its new location. The controls for the spent fuel handling machine are mounted on a console which is located on the spent fuel handling machine trolley. Coordinate location of the bridge and trolley is indicated at the console by digital readout devices which are driven by encoders coupled to the 4 guide rails through rack and pinion gears. Manually operated handwheels are provided for bridge, trolley and winch motions in the event of a power loss.

Safety features of the spent fuel handling machine are as follows:

a. Zone interlocks which will slow and ultimately stop bridge and trolley motion to protect the mast from hitting SFP walls.

b. An interlock that prevents the entry of the SFHM mast carrying a load into a zone adjacent to the south tilt pit when the tilt pit gate is installed and the tilt pit is empty of water. This prevents unacceptable radiation fields in the south tilt pit area.

c. Interlocks which restrict simultaneous operation of either the bridge and trolley or the hoist winch drive mechanism.

d. An override switch which must be actuated after fuel hoist operation to allow bridge or trolley motion.

e. Overload and underload interlocks which stop fuel hoist motion.

f. An interlock which prevents positioning of the spent fuel handling machine over the tilting machine unless the tilting machine is in the vertical position.

The SFHM is fitted with an auxiliary hoist for accessing fuel cells that are difficult to reach with the main hoist, such as those in the North Tilt Pit. The manual tool for the auxiliary hoist is also used to move fuel with the Spent Fuel Pool overhead crane.

11. Reactor Building Crane

The reactor building crane was originally designed as a 125-ton dual girder, single trolley, indoor electric overhead circular traveling bridge crane (Reference 57). In 1970, it was determined that the Reactor Head, including the Control Rods Drive Mechanisms (CRDMs) and the head lift rig, weighed approximately 133 tons. Additionally, the Hydra-set, used to perform the initial lift of the head from the reactor flange, weighed 2 tons. These components together required a load capacity of 135 tons. Consequently, the crane manufacturer was contracted to re-evaluate (up-rate) the crane for this increased load. The manufacturer, Dresser, performed the evaluation, and the crane was re-rated to 135-tons with only minor changes to the hoist gear ratio (Reference 58). The structure of the crane was not modified.

Codes and Standards

The crane was originally designed, constructed and erected in accordance with the requirements of:

a. Electric Overhead Crane Institute (EOCI), Specification #61

b. American Welding Society (AWS) Standard Specifications

c. National Electrical Manufacturers Association (NEMA)

d. American Standards Association (ASA, later ANSI)

e. National Electrical Code (NEC)

f. National Fire Protection Association (NFPA)

Factors of Safety

The following minimum factors of safety, under static full rated load stresses and based on ultimate strength of material were provided:

Material	Factor of Safety	
Cast Iron	12	
Cast Steel	8	
Structural Steel	5	
Forged Steel	5	
Cables	5	
Welds	5	(Based on ultimate strength of metal in weld)

Load Test

The crane was originally load tested to a live load reading of 145 tons (Reference 59). This load reading did not include the weight of the Hydra-set, which weighs 2 tons. Subsequent to the 10-ton up-rate in 1970, the crane was load tested to a load reading of 139 tons. Again, this load does not include the 2-ton Hydra-set weight (Reference 60). Therefore, the maximum load test load lifted by the up-rated crane was 141 tons.

NUREG-0612 Evaluation

In 1983, in association with NUREG-0612, the crane design was re-evaluated by the manufacturer, Dresser, against two newer standards, the Crane Manufacturers Association of America (CMAA), Specification #70-1975, and the American National Standards Institute (ANSI), Standard B30.2-1976, Chapter 2-1. This review determined that the crane met the intent of all of the mandatory electrical, structural and mechanical design requirements of these new Standards, with one exception. The calculated stress in the end tie, for the case where the capacity load is moved to the extreme end approach, was 5.9% over the CMAA-70 allowable stress of 14.4ksi for these components. This condition was deemed insignificant, and was accepted by the Crane Manufacturer, Consumers and the NRC, in their Safety Evaluation Report (see below).

NUREG-0612 also required licensees to evaluate their crane inspection, testing and maintenance against ANSI B30.2, Chapter 2-2, and that operators be trained, qualified and conduct themselves in accordance with B30.2, Chapter 2-3. Palisades responded that its inspection procedures, and its operator-training program and procedures, meet the intent of these two chapters of this Standard.

The Franklin Research Center, in their Technical Evaluation Report, TER-C5506-378, dated 10/15/1983, accepted Palisades response to NUREG-0612, and stated that load handling operations at Palisades met the staffs objectives. The NRC accepted the recommendations of their contractor in the Safety Evaluation Report issued to Palisades on November 9, 1983 (Reference 61).

Reactor Head Drop Analysis

In 2007, an analysis was performed of postulated reactor head drops from the reactor building crane onto the flange of the reactor vessel during reduced primary coolant system inventory conditions (Reference 68). The analysis considered several reactor head drops, including a 31-foot drop of the reactor head, and concluded that reactor vessel support capacity and deflection limits are not exceeded.

9.11.4.4 System Evaluation

Underwater transfer of spent fuel provides ease and safety in handling operations. Water is an effective, economic and transparent radiation shield and a reliable cooling medium for removal of decay heat.

Basic provisions to ensure the safety of refueling operations are:

1. Gamma radiation levels in the containment and fuel storage areas are continuously monitored. These monitors provide an audible alarm at the initiating detector and in the control room indicating an unsafe condition. Continuous monitoring in the control room of reactor neutron flux provides immediate indication and alarm of an abnormal core flux level.

2. Violation of containment integrity is not permitted when the reactor vessel head is removed unless an adequate shutdown margin is maintained.

3. The required refueling boron concentration in the refueling cavity is sufficient to maintain the reactor subcritical by 5% $\Delta\rho$ with all control rods withdrawn. Administrative controls employed during the movement and placement of fuel within the refueling cavity ensure that the 5% $\Delta\rho$ subcriticality margin is maintained during Refueling Operations.

9.11.4.5 Test Program

In addition to the inspections and testing which were performed on individual components as they were fabricated, the major refueling items were shipped to Windsor, Connecticut, where they were assembled at a facility which allowed acceptance and performance testing of the equipment as a complete system. The testing facility simulated the refueling conditions of the Palisades site to allow assembly of the complete refueling configuration. The reactor tilting machine was positioned adjacent to a core and pressure vessel mock-up which was assembled in a pit. Rails were installed between the spent fuel pool tilting machine and the reactor tilting machine. With the refueling machine mounted on rails over the core mock-up, simulated refueling operations were performed as follows:

1. Indexing the refueling machine to the fuel assembly in the core

2. Engaging and lifting the fuel assembly into the fuel hoist

3. Indexing the refueling machine to the tilting machine and lowering the fuel assembly into the carriage

4. Operation of the transfer system to tilt the carriage to the horizontal, transfer it through the simulated refueling tube to the spent fuel pool tilting machine and to tilt the carriage back to the vertical

Heaters were installed in the bottom of the pit to simulate the turbulence caused by decay heat generation.

Subsequent to the completion of this test program at Windsor, the equipment was disassembled and shipped to the site. It was reassembled and sufficient tests performed to demonstrate that it met system requirements. This was part of the preoperational test program performed before fuel loading.

9.11.5 SPENT FUEL STORAGE AT AN INDEPENDENT SPENT FUEL STORAGE INSTALLATION

Approval to store spent fuel at the original Palisades Independent Spent Fuel Storage Installation (ISFSI) was granted by the NRC via Subpart K of 10CFR72. Palisades chose the Pacific Sierra Nuclear VSC-24 system for the original ISFSI. The VSC-24 system was determined by the NRC to meet the requirements of 10CFR72 by the NRC's issuance of the Certificate of Compliance (C of C) on May 7, 1993. The license for each individual cask expires 20 years from the inservice date.

The VSC-24 system places a Multi-Assembly Sealed Basket (MSB) and a MSB Transfer Cask (MTC) in the cask loading area of the spent fuel pool where the MSB is loaded with spent fuel. Once loaded, the MSB is transported inside the MTC to the cask washdown pit using the fuel building crane, where the MSB is seal welded, dried, and backfilled with helium. Using the MTC and the crane, the MSB is then transported to track alley, where the MSB is lowered into a Ventilated Concrete Cask (VCC). A Load Distribution System (LDS) is installed in track alley to assure that the load is distributed to the walls supporting track alley. The loaded VCC is then transported along the LDS to a trailer that carries the VSC to the ISFSI where it is stored. The VSC-24 system is described in detail in the Pacific Sierra Nuclear Safety Analysis Report (Reference 21).

In 2003, a new ISFSI pad was constructed to accommodate the entire Palisades spent fuel inventory generated through 2011, including the casks stored at the existing VSC-24 ISFSI pad. This ISFSI pad was designed for storage of a new dry cask system manufactured by Transnuclear, Inc., Standardized NUHOMS® Horizontal Modular Storage System, as well as the VSC-24 casks. The NUHOMS® system is also licensed under 10CFR72, Subpart K and has a service life of 50 years.

The NUHOMS® Horizontal Modular Storage System provides for the horizontal storage of canisterized spent fuel assemblies in a concrete horizontal storage module (HSM). The NUHOMS® Storage System components consist of a reinforced concrete HSM and a dry shielded canister (DSC) confinement vessel with an internal basket assembly that holds the fuel assemblies. The DSC and the HSM for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel (Reference 50) are described in the NUHOMS® FSAR.

9.11.5.1 Description Of 10CFR72 License Items Which Interface With The 10CFR50 License

This section describes various ISFSI items licensed under 10CFR72 that interface with equipment licensed under 10CFR50.

9.11.5.1.1 Multi-Assembly Sealed Basket And Transfer Cask

The MSB and MTC shell and internals are coated to prevent detrimental effects on fuel pool water chemistry during the time that the MSB and the MTC are in the pool. The MTC shell and internals and the outer shell of the MSB are coated with a paint that facilitates decontaminating the MTC and the MSB upon removal from the pool.

The MTC and the MTC yoke are special lifting devices designed and fabricated to the requirements of NUREG 0612 and ANSI N14.6 per the Certificate of Compliance. The lifting of the MTC is performed under site-specific heavy load requirements that conform to the recommended guidelines of NUREG 0612 and Generic Letter 85-11.

9.11.5.1.2 Transnuclear 32PT-S125 DSC, 24 PTH-S125 DSC and OS-197 Transfer Cask

The Transnuclear OS-197 transfer cask is designed for onsite transport of the 32PT-S125 DSC and 24 PTH-S125 DSC to and from the plant's spent fuel pool and the ISFSI. The transfer cask provides the principal biological shielding and heat rejection mechanism for the DSC and spent fuel assemblies during handling in the fuel building, DSC closure operations, transport to the ISFSI, and transfer into the Horizontal Storage Module (HSM or HSM-H). Two lifting trunnions are provided for handling the transfer cask in the plant's fuel building using a lifting yoke and an overhead crane. Lower support trunnions are provided on the cask for pivoting the transfer cask from/to the vertical and horizontal positions on the support skid/transport trailer. According to the Transuclear FSAR, the transfer cask upper trunnions and trunnion sleeves are designed in accordance with ANSI A14.6 requirements for non-redundant lifting devices. The Transnuclear lifting yoke is designed and tested to the requirements of ANSI N14.6 and NUREG-0612.

The DSC and OS-197 components are primarily constructed of stainless steel materials to prevent detrimental effects on the fuel pool water chemistry during loading and unloading operations.

9.11.5.1.3 Impact Limiting Pads

For the VSC-24 system, impact limiting pads (ILPs) can be placed in the spent fuel pool and the cask washdown pit to support fuel loading, if the crane is not used in accordance with single failure proof requirements. The required pressure ratings for the foam in each of the ILPs was determined by calculating the critical pressures on the slabs beneath the cask loading area and the cask washdown pit. These critical pressures were used to determine the minimum strength of the foam to be placed in the ILPs. Also, the bottom of the spent fuel pool ILP is designed with groove areas to prevent any load from bearing on the pool liner welds. Since the main hoist of the spent fuel crane is now single failure proof, impact limiting pads are not required in the cask loading area of the spent fuel pool and the cask washdown pit when the crane is used in conformance with single failure proof requirements.

9.11.5.1.4 Security For The Independent Spent Fuel Storage Installation

The security system for the VSC-24 ISFSI was installed under Facility Change FC-925 and was later upgraded under the engineering change process. The system was constructed and is maintained per the requirements of 10CFR50 and 10CFR72 Subpart H.

The Transnuclear NUHOMS® ISFSI facility is protected separately and is approximately 2400 feet from the plant Protected Area. The security system for this ISFSI was included as part of the overall ISFSI construction project under Engineering Assistance Request EAR-2000-0309. The tie-ins to the existing plant security system were completed under EAR-2002-0317. This ISFSI security system was later upgraded under the engineering change process.

9.11.5.1.5 Lifting Equipment

The design and description of the rigging equipment used to handle the VSC-24 and the Transnuclear NUHOMS® system components in the auxiliary building is described in References 18 and 48, respectively. The requirements of NUREG-0612 and ANSI N14.6 were applied to this lifting equipment as appropriate.

9.11.5.1.6 Spent Fuel Pool Boron And Temperature Limits

The Certificate of Compliance (C of C) for the VSC-24 system requires that the spent fuel pool boron concentration be greater than or equal to 2850 ppm during cask loading and unloading activities (Reference 19). The required spent fuel pool boron concentration for the Transnuclear NUHOMS® system is 2500 ppm during loading and unloading activities (Reference 50). This ensures that a subcritical configuration is maintained in the case of accidental loading of the MSB or DSC with unirradiated fuel.

For the VSC-24 system, the reaction between carbo zinc primer and borated spent fuel pool water will generate a hydrogen gas and produce zinc borate precipitates that can result in boron depletion. Controls are provided during loading and unloading activities to prevent the hydrogen gas from reaching an explosive level, and to insure that the boron concentration will not be reduced below the C of C limit of 2850 ppm.

The Transnuclear NUHOMS® system design includes the use of aluminum plate, which reacts with the borated spent fuel pool water to form hydrogen gas. As with the VSC-24 system, controls are provided during loading and unloading activities to prevent the the hydrogen gas from reaching an explosive level.

9.12 ULTIMATE HEAT SINK

9.12.1 DESIGN BASIS

The Ultimate Heat Sink structures and components are designed to provide water from Lake Michigan to the suction side of various Plant pumps. Lake Michigan is the ultimate water source for the removal of Plant waste heat during normal operation and removal of decay heat during shutdown and post accident conditions. Following use, the water and waste heat is returned the Lake Michigan through the discharge structure.

Structures, systems and components making up the ultimate heat sink supply are designed to CPCo Design Class 3 and are considered to be non-safety related with the exception of portions of the Intake Structure, which are designed to CPCo Design Class 1 requirements.

The Ultimate Heat Sink and associated structures, systems and components provide a support function to other systems by supplying screened water from Lake Michigan to the Service Water System discussed in Section 9.1, Fire Water System discussed in Section 9.6 and the Circulating Water System/Dilution Water discussed in Section 10.2.4.

9.12.2 SYSTEM DESCRIPTION AND OPERATION

9.12.2.1 System Description

Lake water enters the system through an intake crib located off shore, approximately 3000 feet from the Plant's intake structure. The intake bell, located under the intake crib, is in approximately 25 feet of water. Actual submergence varies based on Lake Michigan water level. The water enters the intake crib and travels through a carbon steel line buried in the lake bottom. Near the intake structure, the line divides into two flow paths, one entering the north and the other entering the south intake structure bays. The flows pass through separate trash racks and traveling screens ensuring that debris is removed prior to reaching pump intakes. Capability to isolate the flow through the use of stop logs is provided upstream from the traveling screens. The two dilution water pumps and one diesel fire pump take suction from this portion of the intake structure (Figure 9-1 Sheet-2, Figure 9-11 Sheet-1 and Figure 10-6).

Water supplying the service water pumps and the remaining firewater pumps flows from the two intake bays through sluice gates into the service water pump intake bay. All three service water pumps, the screen wash pump, the electric fire pump, one diesel fire pump and the fire system jockey pump take suction from the service water intake bay (Figure 9-1, Sheet-2 and Figure 9-11 Sheet-1).

The capacity of the Plant's intake from Lake Michigan greatly exceeds the combined capacity of all the pumps that use the lake as a source of water. The intake was originally designed for the much larger flow rates required to support once-through condenser cooling. The once-through cooling was converted to a closed loop cooling tower design early in the Plant's life. Two of the original four trash rack and traveling screen combinations, however, were removed from service by installing their associated stop logs. The associated traveling screens were then removed and replaced with dilution water pumps in support of the cooling tower configuration and plant discharge requirements.

The traveling screens are normally washed by a dedicated pump. An alternate screen wash water source is provided by the fire protection pump test header.

The water intake is periodically treated to reduce biological growth that can affect long term operation of various heat removal systems (Figure 9-1, Sheet-2).

Level transmitters are provided in the intake structure. The transmitters support local level indication, provide actuation of the traveling screens and provide control room indication and alarm.

After cooling Plant equipment, service water and excess dilution water effluent is released back to the lake, flowing from the makeup basin out through the discharge structure. The two makeup basins are the suction points for the two cooling tower pumps and are connected by an isolatable path through the warm water recirculation pump suction bay. Service water discharge can provide makeup to the cooling towers if dilution water is not available. Excess water flow carrying the waste heat moves from the two makeup basins over stop logs and into the mixing basin where it can be briefly monitored, diluted or chemically treated prior to its discharge into the lake. The stop logs are set to ensure proper level is maintained in the two cooling tower makeup basins (Figure 1-12, Sheet-2 and Figure 10-6).

A warm water recirculation pump can provide heated water from the cooling tower pump makeup basins (condenser outlet) to the intake structure. Flow from the pump discharges into the two intake bays, upstream from the trash racks and traveling screens. Warm water mixes with the intake water to heat the intake water during conditions that promote development of frazil ice. Water enters the warm water recirculation pump bay through sluice gates that are connected to the cooling tower makeup basins. The water can be either pumped or siphoned from the pump bay and discharged into the intake flow (Figure 10-6).

In addition, a 36 inch diameter line was designed to allow alignment of the warm water recirculation pump suction bay to either the mixing basin or directly to Lake Michigan. Flow back through the discharge structure into the mixing basin is now the only credited flow path from Lake Michigan. Though part of the design, the valve on the Lake Michigan side of the discharge structure is not tested due to sand intrusion and sand blockage concerns. Use of either path is limited by lake level (Reference 47). The alignment of the recirculation pump suction to the lake provides an optional source of water to the intake structure in the unlikely event the intake line from the Lake Michigan is lost.

9.12.2.2 System Operation

Ultimate heat sink configuration and operation does not change between normal, shutdown or post-accident operation. During the various plant operating configurations, supported pumps take suction as needed. Flow varies based on head differences that occur as various pumps take water at their intake points thereby reducing water level in the intake structure when compared to the lake.

During operation, the intake bay level is monitored and should low level conditions occur, an alarm will alert the control room to take appropriate action.

The warm water recirculation pump discharge can be aligned to supply warm water to the intake, either though siphoning or pump operation, if icing conditions are present.

The warm water recirculation pump can be aligned to supply water from the discharge structure to the intake structure should the intake line be blocked for any reason.

9.12.3 DESIGN ANALYSIS

9.12.3.1 Margins of Safety

1. The capacity of the intake structure and piping significantly exceeds water demand imposed by all pumps operating at maximum flow.

2. Lake water intake and discharge is a passive design requiring no component alignment to meet Plant water intake and discharge demands for all normal and analyzed accident configurations.

3. Alarms in the control room notify operation personnel that conditions affecting supply of water are occurring allowing time to reduce demand and ensure critical water to safety related systems is available.

9.12.3.2 Provisions for Testing and Inspection

Inspection and testing of structures and components associated with the Ultimate Heat Sink are based on the scope and frequencies outlined in NUREG-0820,"Integrated Plant Safety Assessment - Systematic Evaluation Program" Topic III-3.C, "Inservice Inspection of Water Control Structures" located in Section 4.7.1, Table 4.2. The inspections and testing activities noted in NUREG-0820 are in part, in lieu of annual inspections of the intake crib structure, the intake bell and the other elements of the service water system. In addition, inspections are performed on appropriate elements of the intake and discharge structures and components following unusual events such as significant earthquakes, tornados, or other unusual events that may damage the intake and discharge structures and components.

Testing of the warm water recirculation pump is performed at least annually. This testing includes alignment of the pump to demonstrate its ability to move water from the discharge structure mixing basin to the intake structure. When equipment or lake conditions do not allow for functional testing of the warm water recirculation pump, additional inspections of the intake and discharge structures and components may be performed.

Annual inspection of the intake crib structure is performed following the annual lake ice floe. This inspection checks for damage to the intake crib structure.

Underwater inspection frequencies also consider the rate of accumulation of debris such as sand and zebra mussels in the intake structure and piping. Accumulated debris is removed as part of these routine inspections or on an as needed basis to ensure the structures and components can reliably meet their design functions.

9.12.3.3 Heat Sink at Hot Shutdown Conditions

For achieving and maintaining hot shutdown conditions the ultimate heat sink for decay heat removal is one or both of the steam generators. The steam generators are typically steamed utilizing the code relief valves, or the steam dump and turbine bypass valves, if available. Makeup to the steam generators is supplied by one of three auxiliary feedwater pumps using onsite stored water supply. During the time to reach and maintain hot shutdown conditions, service water is used to cool only plant equipment and the spent fuel pool. Decay heat is discarded to the lake only after shutdown cooling is aligned to cool the primary coolant system.