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(Section 9)

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9. REACTOR PLANT AUXILIARY SYSTEMS

9.1. Reactor Emergency Systems

9.1.1. Emergency Cooling System

9.1.1.1. Function

The emergency cooling system (DK system) removes decay heat from the core when all electrical power supplies except the 300-kw emergency diesel generator are inoperative or when the primary pumps are unavailable for circulating the primary coolant through the core. The DK system is also used during an MCA to assist with pressure suppression within the containment vessel.

9.1.1.2. Description

A schematic flow diagram of the DK system is presented in Drawing DK 48-J-379. There are two loops in the DK system. One circulates primary cooling water through the emergency cooler and pump and then through the reactor; and the other loop circulates salt water by means of a submersible sea water pump through the shell side of the emergency cooler.

The loop which circulates primary cooling water consists of the 240 gpm emergency canned pump (DK-P2) which takes suction from the outlet leg of the primary coolant system port loop. The flow is directed to the helical-coil emergency cooler (DK-C1) which is fitted with a bypass valve (DK-19V) and a flow control valve (DK-20V) so that the operator may control the heat removal rate. The return flow enters the primary coolant system in the starboard loop inlet leg. A remote-operated inlet valve (DK-21V) to the emergency cooling loop along with the two control valves mentioned above provides a means for isolating the system from the primary system when not in use.

The sea water circuit contains the 195 gpm submersible emergency sea water pump (DK-P1), which is located in the lower reactor compartment. The pump discharge line enters the containment, then splits into three parallel circuits which supply cooling water to the emergency cooler (DK-C1), the emergency canned pump (DK-P2) cooling coils, and the emergency containment cooling coils (DK-C2) in the containment cooling system. The return line is routed overboard through either the after crossflooding duct or the auxiliary condenser overboard discharge line. Electrically operated valves (DK-4V and DK-32V) outside the containment are used to isolate the sea water circuit.

The sea water circuit of the DK system is valved so that it can be tested periodically and then flushed with fresh water. The fresh water remains in the system until the next test cycle, or until the system is put into service. Thus, fouling and corrosion due to sea water are reduced.

In addition to the two loops described above, it is possible to add makeup water to the primary system from the deaerator (DC heater) by using the 31 gph emergency makeup pump (DK-P3) located at the B-deck level in the machinery casing. This ability enables the operator to compensate for minor primary system leakage. This portion of the DK system is also utilized to inject soluble poison into the primary system.

Reliability has been a major consideration in the design and location of the DK system. All components with exception of the makeup system and the controls are located within the collision barrier. Power is supplied to the system from the emergency bus feeding from the emergency diesel generator. Sea water suction is provided from either of two sea chests located on opposite sides of the ship. Additionally, the main fire system is tied in as a backup sea water supply. Sea water discharge is normally through the bottom of the vessel at the centerline. However, in case of grounding, an alternate discharge is provided through the port side.

9.1.1.3. Operation and Control

The DK system is maintained in a state of readiness for instant operation. The system is placed into operation automatically by interruption of power from the main electrical bus or by a trip signal from the primary pump monitor circuit. It can also be started manually from a single pushbutton at the main control console. A simultaneous signal from these sources also starts the emergency diesel generator thus assuring power to the system.

Once the system is in operation, the operating station located in the emergency generator room on the navigation deck must be manned and the rate of primary system cooling regulated from that point. Necessary instrumentation and individual controls for the various system components are provided on the emergency cooling panel. The operator at the control station has telephone communication with the personnel in the main control room.

9.1.1.4. Tests and Performance

The DK system and the emergency diesel generator are tested for operability at a minimum frequency of once a week. The system is also tested prior to plant startup from any extended outage and following any system maintenance.

The heat removal rate is checked at least quarterly to assure that the specified rate of 4×10^6 Btu/hr is maintained. Tests results indicate that under normal operating conditions the system will remove about 5.6×10^6 Btu/hr.

9.1.2. Soluble Poison System

9.1.2.1. Function

The soluble poison system (SP system) is an alternate means of reactivity control for reactor shutdown. The system is capable of overriding sufficient reactivity to permit the operator to bring the reactor to a cold, subcritical condition with all control rods withdrawn from the core. The system will hold down approximately 11% excess reactivity (a boric acid concentration of approximately 4½ gm/liter).

9.1.2.2. Description

The SP system (see Drawing SP 28-J-401) consists of a 28 cubic foot mixing tank (SP-T1) containing two immersion heaters (SP-H1 and SP-H2), an agitator (SP-F1), valves and piping. The mixing tank is located in the machinery casing at the navigation bridge level.

9.1.2.3. Operation and Control

Since the SP system has a slow response and will be used only following a major accident, the system is operated manually. The boric acid is stored in crystal form to avoid the difficulties of long-term storage of concentrated boric acid solutions. For ease of handling, prepackaged boric acid crystals (400 pounds) are added to hot water in the mixing tank and agitated to form a uniform solution. Recrystallization of the boric acid solution is prevented by maintaining the solution temperature at 200 F. The solution temperature is maintained by immersion heaters, which are controlled by the thermostat (TC/SP-2).

After the crystals have dissolved, the solution is pumped from the mixing tank into the DK system with the emergency makeup pump (DK-P3) at the rate of 31 gph. The boric acid is circulated into the primary system by the 240 gpm emergency canned pump (DK-P2), which, with or without assistance from the primary coolant pumps disperses the boric acid solution uniformly throughout the primary system water. The rate of boron addition is slow, requiring about 5 hours to reach a concentration of 4½ gm/liter in the primary coolant. However, the rate of poison injection is sufficient for reactivity holddown when the reactivity effects of xenon buildup and decay and the primary system cooldown are considered.

To provide maximum flexibility of operation, power requirements have been kept to a minimum so that the system may be operated on power from the 300 kw emergency diesel generator.

9.2. Reactor Auxiliary Systems

9.2.1. Primary Loop Purification System

9.2.1.1. Function

The principal function of the primary loop purification system (PP system) is to assure that the impurity concentrations in the primary coolant are below specified levels. These impurities can consist of dissolved and undissolved corrosion products and residual impurities in the makeup water. Gases (argon, xenon, krypton, and helium) are not removed by the PP system.

Secondary functions of the PP system are:

1. Supply makeup water to the buffer seal system.
2. Remove decay heat during reactor shutdown.
3. Decontaminate the primary coolant if a fuel rod should fail.

9.2.1.2. Description

The PP system (see Drawing PP 21-J-375) consists of four letdown coolers; three demineralizers; two filters; and associated instrumentation, controls, valves, and piping.

The four letdown coolers (PP-C1, PP-C2, PP-C3, and PP-C4) are identical shell and tube heat exchangers arranged in two parallel loops, each loop containing two letdown coolers in series. Cooling water for the letdown coolers is supplied by the intermediate cooling water system. Isolation valves (PP-1V, PP-2V, PP-3V and PP-4V) are located upstream and downstream of each pair of coolers and are operated by pushbuttons on the main console. The valve arrangement permits operation with either pair of coolers. With the primary system at normal operating conditions (521 F and 1750 psig), the cooler heat load is 4.3×10^6 Btu/hr at the normal flow rate of 20 gpm. Each pair of coolers are capable of handling the maximum heat load of 9.8 x 10^6 Btu/hr when 45 gpm (110 F and 50 psig) is flowing through the system.

The carbon steel shell of each cooler is about 30 inches in diameter and about 21 inches long. The tube side, in which primary water circulates, is designed for 2000 psig and 650 F. The shell of each cooler is designed for 150 psig and 225 F. The coolers are located inside the containment vessel.

The mixed-bed demineralizers (PP-E1, PP-E2, and PP-E3) are in the forward area of the secondary shield. Each unit is capable of handling a flow up to 30 gpm; therefore, with a normal system flow of 20 gpm, only one demineralizer is in operation. Flows above 30 gpm require two units.

The demineralizers are upright cylindrical tanks, 30-inch ID and 5-foot high, with hemispherical heads. Each demineralizer is surrounded with 4½ inches of lead shielding. Each tank contains 17.5 cubic feet of nuclear grade mixed-bed resin with a 1.5 to 1 volume ratio of cation resin to anion resin. The resin bed depth in the units is about 42 inches and is supported by a perforated plate. Course and fine mesh screens on top of the plate retain the resin in the demineralizer tanks. A header at the top of the tank distributes the primary system water, which flows down through the resin. Remotely operated isolation valves (PP-11V, PP-12V, PP-13V, PP-26V, PP-27V and PP-28V) are located on the upstream and downstream sides of each demineralizer. These valves are operated by pushbuttons on the main console.

The effluent filters (PP-E4 and PP-E5) are located at the outlet of the demineralizers in the forward area of the secondary shield. These units are identical in design and are capable of removing resin fines and insoluble impurities from the demineralizer effluent. Each unit is capable of handling flows up to 30 gpm; therefore, at the normal flow of 20 gpm, only one unit is used. Each filter is about 12 inches in diameter and 32 inches long and is surrounded with 2 inches of lead shielding. The demineralizer effluent enters the filter through a side connection near the bottom, flows upward through the filter elements, and out through a side connection near the top. The filter elements consist of three hollow cartridges of sintered stainless steel. The mean pore opening in the cartridges is 10 microns. A bolted cover plate is located on the top of the unit so that the entire filter assembly can be removed. Isolation valves (PP-30V, PP-31V, PP-37V, and PP-38V), activated by pushbutton on the main control console, are located on each side of the filters.

The PP system water flows into the top of the buffer seal surge tank (SL-T1) after leaving the effluent filters. This line contains a flow nozzle from which flow is measured by means of a differential pressure cell (FI/PP-10). The detected flow is transmitted by a pneumatic signal to the main control room and is indicated on the main console.

9.2.1.3. Operation and Control

During normal reactor operation, primary water at approximately 521 F and 1750 psia is drawn from the reactor outlet line of the port primary coolant loop. This water flows through the letdown coolers and the normal flow control valves (PP-7V or PP-8V) to reduce the temperature and pressure to about 110 F and 50 psig. The water then passes through the demineralizer and the effluent filters. The filtered water flows into the buffer seal surge tank (SL-T1) prior to reentering the primary system.

The PP system is designed to maintain the total solids content of the primary coolant at less than 3 ppm and the total dissolved solids at less than 1 ppm. Normal flow through the system is about 20 gpm (110 F and 50 psig), but if necessary a flow of up to 45 gpm (110 F and 50 psig) can be maintained. The system is capable of handling up to 60 gpm at low primary system temperatures (300 F or less).

The flow control network, located downstream of the letdown coolers and inside containment, consists of the two normal flow control valves (PP-7V and PP-8V) and a bypass control valve (PP-6V). Valves PP-7V and PP-8V are diaphragm operated angle valves and are used to control the system flow when the primary system pressure is above 500 psig. When the primary system is at the normal operating pressure (1750 psia), each flow control valve is capable of handling flows up to 37 gpm.

The normal flow control valves are not capable of handling sufficient flow when the primary system pressure is reduced below 500 psig (during heatup and cooldown of the primary water). The bypass control valve (PP-6V) provides flow during these periods. This valve is a diaphragm operated, straight-through valve.

Downstream of the flow control valves the PP system piping penetrates the containment vessel wall and enters the area inside the secondary shield. A diaphragm operated valve (PP-57V) is located in this line immediately outside the containment vessel. This valve is operated by the containment isolation system.

A flow measurement nozzle is located in the line downstream of valve PP-57V. The flow is detected by a differential pressure cell (FICA/PP-3) and is transmitted by a pneumatic signal to a flow indicator on the main control console. Valve PP-7V or PP-8V can be controlled in the automatic mode at a preset flow rate by a signal from the cell. The signal also actuates high and low flow alarms on the annunciator panel. Valves PP-6V, PP-7V, and PP-8V can also be operated in the remote manual mode from the main control console.

A pressure detector (PIA/PP-6) and two temperature detectors (TICA/PP-4) are located in the same general area as the flow nozzle. The pressure is sensed with a bourdon tube type detector and is transmitted by a pneumatic signal to the main control room. This signal actuates a pressure indicator on the main control console and a high pressure alarm on the annunciator panel. Each of the two temperatures is detected with a gas filled sealed system consisting of a temperature bulb connected by capillary tubing to a bourdon tube. The detected temperatures are independently transmitted by pneumatic signals to a selector switch on the main control console. This switch is used to select which one of the two signals will be used to actuate:

1. A temperature indicator on the main control console.

2. A high temperature alarm on the annunicator panel.

3. Temperature monitoring and print out (both normal temperature and high alarm temperature) by the data acquisition system (DA system).

4. Control of the diaphragm operated valve (CW-39V) in the intermediate cooling system, which controls the cooling water flow to the letdown coolers.

The demineralizers are arranged so that the spent resin may be removed by sluicing with the unit in place on the ship or by removing the entire unit from the ship for subsequent sluicing. Currently, spent resin is sluiced into a portable tank. Each demineralizer unit has two flanged sluicing connections, 180 degrees apart, at a point just above the resin retention screen. Shielded hoses connect the demineralizer, pump, and portable tank. The pump takes suction from the portable tank and supplies water to the demineralizer. The resin-water mixture then flows into the sluicing tank where a filter separates the resin from the water. After the sluicing operation is completed, the tank containing the spent resin and sluicing water is transferred to shore for off-site disposal. New resin is added to the demineralizer through a flanged filling connection located on the top of the unit. Venting and draining operations associated with demineralizer units are made with a vent line connected to the gas manifold in the gaseous waste disposal system (WL system) and with a drain line connected to the equipment drain and waste collection system (PD system).

The pressure drop across the filters is detected with differential pressure cell (PdIA/PP-7) from which a signal is transmitted pneumatically to the main console. The signal is used to actuate a differential pressure indicator on the main console and a high differential pressure alarm on the annunciator panel. A high differential pressure across the filters indicates that backflushing is required to remove the filtered material. Flush water is supplied from the combined condensate pump discharge in the engine room. The water first passes through a rotameter (PP-F18) in the engine room and then through individual backflushing lines for each unit. Manual valves (PP-49V and PP-50V) on the backflush lines connect to the normal outlet nozzle at the top of the filter. About 30 gpm of flush water flows counter to the normal flow path. The flush water leaves the filter through a drain connected to the laboratory waste tank.

When fresh makeup water is required for the buffer seal surge tank, it is added by the PP system. Makeup water is added to the main PP system flow path upstream of the demineralizers. Makeup water is normally supplied from the outlet of the combined condensate polishing demineralizer in the secondary system. When additions are made, manual control valves (PP-73V and PP-74V) and a local flow indicator, located near the polishing demineralizer on the lower level of the engine room, are used for makeup flow control. The makeup flow is about 5-10 gpm. The rate of addition can also be monitored in the control room by comparing difference in the flow downstream of the letdown flow control valve network and the flow to the buffer seal surge tank.

A second source of makeup water is the primary system expansion water stored in the makeup storage tanks (PD-T2 and PD-T3). This source is usually used during cooldown of the primary system. The primary makeup pump (PD-P2) is used to add the makeup water to the upstream side of the demineralizers. A flow nozzle is located in the makeup line. The flow is detected with a differential pressure cell (FI/PP-1) and the signal is transmitted pneumatically to the main control room for indication on the main control console. The makeup flow from this source can also be monitored by comparing the flow indications produced by instruments FICA/PP-3 and FI/PP-10. Flow rates up to 50 gpm can be supplied by this method.

Three sets of relief valves are provided to prevent excessive pressures in the PP system. A relief valve (PR-4V, set at 150 psig) is connected to the main piping downstream of the flow control valves and discharges to effluent condensing tank (PR-T1). This valve prevents excessive pressure buildup in the low pressure piping and equipment (186 psig design) if the main purification flow is shut off by closing the isolation valves on a filter or a demineralizer when one of the flow control valves is open. Each demineralizer is provided with a relief valve (PP-63V, PP-64V, or PP-65V, set at 60 psig) on the outlet line. The three valves discharge into a common header which is routed to the backflush outlet nozzle for effluent filter PP-E5. Each effluent filter has a relief valve (PP-62V or PP-61V, set at 60 psig) which discharges to the buffer seal surge tank.

The PP system supplies water for the two sampling system loops. The supply line for one loop is connected to the piping between the letdown coolers and the flow control valves. The return line for this loop is connected to the main purification piping between the flow control valves and the demineralizers. The supply line for the second sample loop is connected to the main line between the demineralizers and effluent filters; the return water for the second loop flows into the buffer seal surge tank.

The pressurizer can be vented to the PP system through a 1-inch line (WL-2) which is connected to the PP system piping between the letdown coolers and the flow control valve network. A diaphragm operated valve (WL-1V) is used for the venting operation.

9.2.1.4. Tests and Performance

The normal water losses from the primary system have been mainly due to the leakage at the seals of the buffer seal charge pumps and at the primary system safety valves. The fresh makeup requirements during normal power operation are 50-100 gallons per day.

The effluent filters require back-flushing once every 2 to 3 months during normal operation. The amount of flush water required is very small, because experience has shown that only a few seconds backflush is required.

The demineralizers are designed to provide at least 50 days of service while removing the corrosion products (formed at an assumed corrosion rate of 10 $mg/dm^2/mo$) so that the total dissolved solids content of the primary system is maintained below 1 ppm. Experience indicates that the design is extremely conservative because the total dissolved solids content of the primary water is normally about 0.2 ppm and the resin in each of the three demineralizers lasts up to 3 years.

The demineralizers are also designed to collect and retain about 400 curies of activated corrosion products and 2500 curies of fission products. The lead shielding is designed for these activities. Based on radiation surveys around the surface of the portable resin sluicing tank after resin has been sluiced, the total accumulated activity in a demineralizer is about 6-8 curies.

During plant operation, the radioiodine in the primary coolant has been about 3×10^{-4} μc/cc, and the radiostrontium has been about 2×10^{-6} μc/cc. The primary coolant gross 15-minute degassed activity has averaged about 5×10^{-2} μc/cc. Fifteen minute degassed samples of the demineralizer influent and effluent indicate that the decontamination factors for activated products in the coolant have been at least 500 and, for a majority of the time, have been more than 3000.

9.2.2. Buffer Seal System

9.2.2.1. Function

The principal function of the buffer seal system (SL system) is to supply purified high pressure water to the control rod drive buffer seals. The high pressure water maintains a seal at penetrations in the reactor head thus preventing primary water leakage. The SL system serves the following secondary functions:

1. Supplies high purity makeup water to the primary system.
2. Provides water circulation through the reactor and purification system when the letdown coolers are used to remove reactor decay heat.
3. Maintains dissolved hydrogen in the primary water.
4. Removes expansion water from the primary system during reactor heatup.

9.2.2.2. Description

The SL system (see Drawing SL 37-J-391) consists of the buffer seal surge tank, two booster pumps, three charge pumps with desurgers, two buffer seal coolers, and associated valves and piping.

The buffer seal surge tank (SL-T1) is the collection point for the water flowing into the SL system from the PP system, for water returning from the control rod buffer seals, and for the bypass flow around the buffer seals. This is a stainless steel, vertical cylindrical tank designed for 186 psig. The tank is 13½ feet tall, 4 feet ID, and has a volume of 87 cubic feet. The gas stripping column, mounted on top of the buffer seal surge tank, is filled with polyethylene packing.

The buffer seal surge tank is located in the forward area of the secondary shield on the port side. The main outlet is routed through the secondary shield to the suction of the two buffer seal booster pumps (SL-P4 and SL-P5), which are mounted on the forward bulkhead of the port stabilizer room. Another line, connected to the tank outlet and containing a diaphragm operated valve (PD-32V), is used to drain excess water to the waste storage tanks (PD-T2 and PD-T3) in the PD system. The valve is operated with pushbuttons on the main control console. The draining operations are normally performed during heatup of the primary system to remove the excess expansion water.

Because of the long lengths of the piping between the buffer seal surge tank and the buffer seal charge pumps (SL-P1, SL-P2, and SL-P3), two booster pumps are provided to assure that the charge pumps have a sufficient net positive suction head. The booster pumps (SL-P4 and SL-P5) are vertically mounted centrifugal pumps that are piped in parallel (one pump on standby). Each pump delivers 140 gpm at a head of 117 feet. The pump volute, impeller, and shaft are made of stainless steel. The pump shaft has a mechanical seal which prevents water from leaking to the atmosphere. Drain lines are provided for the pump casing and seal. Drainage is routed to the drain well located in the forward area of the secondary shield. Manual isolation valves (SL-37V, SL-38V, SL-40V and SL-42V) are located on each side of the pumps, and check valves (SL-39V and SL-41V) are located in the discharge lines. A pressure relief valve (SL-68V, set at 150 psig) is connected in parallel with the pumps. The booster pumps are normally operated from the main console but they can also be operated from local switches in the port stabilizer room.

The discharge pressure of the booster pumps is detected with a bourdon tube and is transmitted by a pneumatic signal to the main control room. This signal (PIA/SL-3) is used to indicate pump discharge pressure and to actuate a low header pressure alarm on the annunciator panel.

The booster pump discharge piping (charge pump suction piping) is routed along the port side of the ship and along the cross flooding passage to the three charge pumps. The charge pumps are located in two small outboard compartments forward of, and adjacent to, the engine room on the lower level.

The starboard room contains charge pump SL-P1, while the port room contains charge pumps SL-P2 and SL-P3. The access openings to these rooms are located in the engine room bulkheads. The main functions of the charge pumps are to deliver the required flow to the control rod buffer seals and to supply primary system makeup water. The charge pump is a vertical triplex, single acting pump; i.e., reciprocating type with three plungers. The pump is driven by a two speed gear motor through a flexible coupling mounted on a horizontal structural steel frame. The pump delivers 70 gpm at full speed and 35 gpm at half speed. The motor has a rating of 100 hp at full speed and 50 hp at half speed. The pump is capable of delivering discharge pressures up to 2050 psig at both speeds. The seals on the plunger shafts are arranged so that any water that may leak past the seals is collected in a header which drains to a 22-gallon collection tank.

The pumps are piped in parallel with manual isolation valves (SL-1V, SL-2V, SL-3V, SL-46V, SL-48V and SL-50V) located on each side of the pumps. Check valves (SL-4V, SL-47V and SL-49V) are also located in the discharge piping of the pumps. Relief valves (SL-43V, SL-44V and SL-45V) set at 2250 psig are connected between the discharge and suction of each pump to prevent excessive pressures if the discharge flow is isolated while the pump is operating.

Reciprocating pumps have pressure pulsations which can be as high as ± 30 to 40% of the discharge pressure. These pulsations can be detrimental to the control rod buffer seals. Consequently, an electrically heated desurger (SL-T2, SL-T3 or SL-T4) is connected to the discharge of each charge pump. The desurgers reduce the pressure pulsations to $\pm 2\%$ of the pump discharge pressure. The desurgers are 3-foot sections of 4-inch stainless steel pipe wrapped with two sets of 1.225 kw wrap-around heaters. The heaters are used to form and maintain steam in the desurgers. Temperatures in the desurger are sensed with two thermocouples located on the outside surface. The sensed temperature is transmitted to a controller in the main control room. The controller automatically controls the heaters.

The discharge piping for a charge pump SL-P1 in the starboard pump room is routed along the cross flooding passage behind the secondary concrete shield and joins with the discharge header for pumps SL-P2 and SL-P3 at a point just forward of the port pump room. The common line then returns to the port stabilizer room where two strainers (SL-F9 and SL-F10) are located in the line. The strainers are required to prevent plugging of the internal bypass orifices in the control rod seals. The openings in the strainer screen are 0.02 inches. The orifice diameter is 0.045 inches. The pressure drop across the strainer is measured with a differential pressure cell (PdIA/SL-18), and the signal is transmitted pneumatically to the main control room for indication on the main control console and for a high differential pressure alarm on the annunciator panel.

Two pressure detectors are located directly downstream of the strainers. One detector (PI/SL-12) is a bourdon tube type directly connected to a local reading gage. The gage monitors the pressure of the control rod seal header when the pressure is being controlled manually. The second detector (PI/SL-1) is also a bourdon tube type and the detected pressure is transmitted to the main control room. The signal is used for:

1. A pressure indicator on the main control console.
2. A differential pressure controller (PdCA/SL-1) which in conjunction with a signal from the primary system pressure instrumentation (PIRA/PS-5) regulates the bypass control valve (SL-9V) so that the buffer seal header pressure is maintained 50 psi above the primary system pressure.

Immediately downstream of the pressure detector, flow is routed to the control rod buffer seal supply header, the buffer seal header bypass line, and the primary system makeup lines through valves SL-121V and SL-6V. The supply line for the control rod buffer seals is routed through the secondary concrete shield and the containment vessel wall to a circular header surrounding the control rod drive structure. A manual isolation valve (SL-11V) is located just outside the secondary shield (in the port stabilizer room). Check valves (SL-87V and (SL-5V) inside the secondary shield area and the containment prevent reactor water from leaking outward through the seals.

A flow nozzle (FIA/SL-9) is located upstream of the manual isolation valve (SL-11V). The flow is measured with a differential pressure cell and the signal is transmitted pneumatically to the main control room where it is used for indication of flow to the seals and for a high flow alarm on the annunciator panel.

From the circular buffer seal supply header, the flow is directed to the 21 control rod seals. At the seals, part of the flow leaks into the reactor vessel, and the remainder leaks outward to a leak-off connection. The outward leakage from each seal is collected in the outlet header and then is returned to the buffer seal surge tank by way of the buffer seal coolers (SL-C1 and SL-C2).

The buffer seal coolers remove heat added to the buffer seal water by the buffer seal charge pumps. The coolers are shell and tube heat exchangers designed to remove 338,000 Btu/hr. Buffer seal water, the tube side fluid, enters at about 130 F and is cooled to about 115 F. Cooling water from the intermediate cooling system flows through the shell side. The cooling water flow is controlled by a diaphragm operated valve (CW-129V) which is manually operated from the main control console. The tubes are made of stainless steel, and the shell is made of carbon steel.

A relief valve (SL-61V), set at 100 psig, is connected across the primary side of the coolers. This valve is provided to relieve excessive pressures if the isolation valves (SL-33V, SL-34V, SL-35V, and SL-36V) on the buffer seal coolers are closed when the flow path from the control rod buffer seals or the bypass line is still open.

9.2.2.3. Operation and Control

The buffer seal surge tank, which receives water from the PP system, operates with a hydrogen overpressure of about 30 psig. The hydrogen overpressure is maintained to supply dissolved hydrogen (20-25 cc/liter) to the primary system water. Water from the PP system is sprayed into the gas stripping column on top of the buffer seal surge tank. As the water flows down the column, the water is saturated with hydrogen.

The buffer seal surge tank can be vented to a gas manifold in the WL system by means of a diaphragm operated valve (WL-34V). This valve is actuated by a switch located on the instrument panel at the sampling station above the forward area of the secondary shield. The tank has a relief valve (SL-10V), set at 180 psig, to prevent excessive pressures. Hydrogen is added to the tank through distribution nozzles located below water level to disperse the hydrogen in the water.

Pressure, temperature, and water level instrumentation are provided for the tank. For added reliability the water level is detected by two differential pressure cells (LIA-SL5) connected to separate standpipes. The two detected levels are independently transmitted by pneumatic signals to a selector switch on the main control console. This switch is used to select the signal, which is used to:

1. Actuate a level indicator on the main control console.
2. Actuate high and low level alarms on the annunciator panel.
3. Shut off the buffer seal booster pumps.

The temperature of the water in the surge tank is detected with a sealed gas-filled system (TIA/SL-6) consisting of a temperature bulb connected by capillary tubing to a bourdon tube. The detector is located in an enclosed thermowell in the tank wall. The temperature (normally 110-120 F) is transmitted pneumatically to the main control room where the signal is used to actuate:

1. A temperature indicator on the main console.
2. A high temperature alarm on the annunciator panel.
3. Temperature logging (both normal temperature, and high and low alarm temperatures) by the DA system.

The pressure (normally 30 psig) in the gas space of the tank is detected with a bourdon tube instrument (PIA/SL-7). The detected pressure signal is transmitted pneumatically to the:

1. Control room for indication on the main control console and for high pressure alarm on the annunciator panel.
2. Hydrogen addition room for use during hydrogen additions.
3. Sampling station for use during sampling.

Since the water letdown from the primary coolant system must pass through the gas space in the buffer seal surge tank, any dissolved gaseous fission products will collect in this gas space. The SL system is designed and operated in a manner which, in the event of equipment failure, will prohibit release of these gases. In normal operation the liquid level of the buffer seal surge tank is maintained at such a level that, if the tank is depressurized by loss of water through the outlet pipe, sufficient water will remain in the tank to prevent loss of gases. The outlet pipe contains a loop seal to prevent water from leaking out of the tank after depressurization. The inlet to the buffer seal surge tank from the buffer seal coolers contains a check valve which prohibits flow out of the surge tank in the event of a failure in the buffer seal coolers or buffer seal charge pumps.

The three reciprocating charge pumps increase the water pressure to about 50 psi above that of the primary system. The water is distributed to the:

1. Twenty-one control rod drive buffer seals.
2. Makeup lines to the primary system.
3. Bypass control line.

Currently, the total inward leakage at the seals and the total return flow are each about 10 gpm. Since the present total flow requirements for the control rod buffer seals are about 20 gpm, two buffer seal charge pumps are operated on half speed. Half speed operation is desirable because the pumps operate more smoothly, and thus, pressure pulsations and discharge pipe vibrations are reduced.

The constant volume flow produced by the buffer seal charge pumps is in excess of the total flow supplied to the seals and to the primary system as makeup. This excess flow is returned to the buffer seal surge tank through a bypass control valve (SL-9V). The valve is automatically controlled with pressure differential controller (PdCA/SL-1) to maintain a pressure difference of 50 psi between the primary system and the buffer seal supply header. The valve can also be operated in the manual mode at the main control console.

The OPEN and CLOSED limit switches for valve SL-9V can be used to automatically control the operation of the charge pumps. If the flow demand increases, the control valve closes to maintain the 50 psi differential. If the valve actuates the CLOSED limit switch, an electrical signal from the limit switch is fed to the controls for the pumps. This signal causes an operating pump to increase to full speed if it is operating at half speed or causes a standby pump to start at half speed. If the flow demand decreases and valve SL-9V actuates the OPEN limit switch in trying to maintain the 50 psi differential, an operating pump is reduced to half speed, or a pump operating at half speed is shut off. The selections for automatic and manual operation of the charge pumps are made with the control switches located on the main console.

Valve SL-9V is designed to control the bypass flow when the primary system is at normal operating pressure. The port area in the valve is not large enough to maintain proper flow at low pressure. During low pressure operation a manual control valve (SL-60V), connected in parallel with valve SL-9V, is used to help control the flow.

Inside the secondary shield area the buffer seal outlet line contains a diaphragm operated valve (SL-8V). It is operated by the differential pressure controller (PICA/SL-1) which regulates bypass control valve SL-9V. If the differential pressure between the buffer seal supply header and the primary system becomes low, valve SL-8V automatically closes to prevent primary system water from leaking out through the seals. Valve SL-8V is also operated by a signal from the containment isolation system. The valve is also operated by pushbuttons on the main console.

A flow nozzle (PIA/SL-4) is located on the buffer seal water return line in the port stabilizer room.

The flow is detected with a differential pressure cell and is transmitted by a pneumatic signal to the main control room for indication on the main control console and for a high flow alarm on the annunciator panel. This instrument is used to monitor the total buffer seal return flow.

Each buffer seal outlet line contains a turbine type flow meter (FE-1/SL-16 through FE-21/SL-16). The sensed flow is electrically transmitted to a panel in the control rod hydraulic equipment room located on the starboard side of the reactor compartment on B-deck. At the panel, a switching arrangement is provided so that the outward flow from any one of the seals can be monitored over a period of time for significant changes.

In the port stabilizer room the bypass flow and the seal return flow join and flow to the buffer seal coolers. The common line contains a flow nozzle which is used to monitor the total return flow to the buffer seal surge tank. The flow is detected with a differential pressure cell (FI/SL-10) and is transmitted to the main control room by a pneumatic signal which is used for indication on the main control console.

The temperature of the primary water leaving the buffer seal coolers is detected with a sealed gas-filled system consisting of a temperature bulb connected by capillary tubing to a bourdon tube (TIA/SL-11). The detector is located in a thermowell in the piping. The detected temperature is transmitted pneumatically to the main control room where it is:

1. Displayed on the main control console.
2. Checked for a high temperature (annunciator panel).
3. Logged (both normal temperature and high alarm temperatures) by the DA system.

The normal temperature leaving the coolers is about 115 F. The temperature indication on the main control console is used to adjust the intermediate cooling water flow to the buffer seal coolers.

Since the 20 gpm flow through the purification system is in excess of the 10 gpm inflow to the reactor through the control rod buffer seals, it is necessary to supply makeup water directly to the primary system. Makeup is supplied from a point located downstream of strainers SL-F9 and SL-F10. Two arrangements are provided for adding the makeup. The normal makeup point is the outlet plenum of the boilers. The auxiliary makeup point is the reactor inlet of the primary system starboard loop.

Makeup water flow to the outlet plenum of the boilers is controlled by diaphragm operated valve SL-121V. This valve is automatically operated from signals from the pressurizer level indicator (LICRA/PE-1). Downstream of valve SL-121V the makeup line branches into two lines. Both lines penetrate the secondary shield and the containment vessel wall. One line is connected to the port boiler outlet plenum while the other line is connected to the starboard boiler outlet plenum. This permits makeup to either boiler.

The auxiliary method of adding makeup is by diaphragm operated valve SL-6V. This is connected to the body of valve PS-6V which is located on the reactor inlet line for the starboard primary loop. Valve SL-6V is controlled by a manual loader located on the main control console.

9.2.2.4. Tests and Performance

The design capacity of the SL system is 126 gpm total flow to the 21 control rod buffer seals or 6 gpm to each seal with 1 gpm flowing inward and 5 gpm flowing outward. Tests on prototype buffer seals indicate the flow requirements to the seals at the end of life is expected to be 1.5 gpm per seal of which 0.75 gpm is inward leakage and 0.75 gpm is outward leakage. Currently, the total flow requirement for the seals is about 20 gpm - the flow to each seal being about 1 gpm with 0.5 gpm inward and 0.5 gpm outward leakage.

In addition to monitoring the control rod buffer seals during normal operation with flow indicators, the buffer seal shafts are visually inspected periodically for wear. Water leakage at buffer seal charge pump plunger shafts is significant. This leakage is collected and routed to 22-gallon tanks located in the pump rooms. The water in the tanks is subsequently transferred to the inner bottom tanks in the PD system.

9.2.3. Hydrogen Addition System

9.2.3.1. Function

The hydrogen addition system (HA system) provides a hydrogen gas blanket or pressure over the water in the buffer seal surge tank. This gas blanket maintains a hydrogen concentration in the primary system water of 20 to 40 cc per liter at standard temperature and pressure (STP). The dissolved hydrogen combines with the oxygen resulting from radiolytic decomposition. Maintaining a low oxygen content in the primary water reduces the corrosion rate of the primary system materials to a minimum.

9.2.3.2. Description

The HA system, as shown schematically in Drawing HA 26-J-393, consists of standard 200 standard cubic feet (SCF) hydrogen cylinders, pressure regulators, valves, piping, and instrumentation.

The hydrogen cylinders (HA-T1, HA-T2, and HA-T3) and regulators (HA-F1 and HA-F2) are located in a special vented locker on the forward weather deck. The hydrogen is introduced into buffer seal surge tank (SL-T1). Distribution nozzles located below normal water level in the tank disperse the hydrogen in the water. A gas stripping column located on top of the tank helps dissolve hydrogen into the water entering the tank from the PP system. The hydrogen pressure in the buffer seal surge tank is maintained by two gas pressure regulators, which are normally operated manually but are also equipped for automatic operation.

A relief valve (HA-10V, set at 60 psig) is provided to relieve the pressure in the hydrogen charge line if the pressure regulator fails. Additionally, the two check valves (HA-18V and HA-19V), connected in series downstream of the regulators, act as a flame arrestor.

A solenoid valve (HA-21V) downstream of the relief valve will isolate the hydrogen manifold if the hydrogen supply line is accidentally severed. The solenoid valve is operated by a pressure switch (HA-10) located downstream. This switch is set to actuate when the pressure drops to 2 psig. The line from the hydrogen addition locker to the buffer seal surge tank is enclosed by a specially vented outer pipe which further minimizes any hazards associated with hydrogen.

9.2.3.3. Operation and Control

Hydrogen is added to the buffer seal surge tank by manual operation of the HA system. The concentration of hydrogen in the primary system water is determined by analytical equipment in the sampling system (SA system). If the dissolved hydrogen concentration is below 20 cc per liter and the pressure in the buffer seal surge tank is low, hydrogen is added to the tank to increase the gas overpressure. A gage indicating the pressure in the buffer seal surge tank is located in the hydrogen addition locker. This gage monitors the pressure while hydrogen is being added.

Air samples are continuously monitored in three areas with explosive gas analyzers so that any hydrogen leakage can be instantly detected. The three areas are:

1. Reactor space air at the discharge of the exhaust fans (RS-P1 and RS-P2).
2. Containment vessel air at the discharge of the containment cooling fans (CC-P1 and CC-P2).
3. Lower void space near the buffer seal surge tank (SL-T1).

If the hydrogen concentration in any of these areas should reach 1% hydrogen (by volume), the explosive gas analyzer will activate an annunciator in the main control room.

9.2.3.4. Tests and Performance

Routine analyses of the primary system water have demonstrated that the free oxygen content of the water is less than 0.01 ppm; therefore, the free oxygen analyses have been discontinued. Operational data indicates a gas overpressure of 28 to 30 psig in the buffer seal surge tank results in a dissolved hydrogen concentration of about 20 to 25 cc per liter of water. Although this deviates from Henry's law (at 30 psig the predicted concentration of dissolved hydrogen is 40 cc per liter), the deviation may be due to the effect of other dissolved gases on the solubility of the hydrogen.

The hydrogen consumption varies according to the mode of plant operation. During normal power operations about 200 SCF of hydrogen (one standard cylinder) are used every 2 months. The hydrogen consumption is primarily through primary coolant leakage at the pressurizer safety valves (PR-1V, PR-3V, and PR-24V) and at the plunger shaft seals for the buffer seal charge pumps (SL-P1, SL-P2 and SL-P3). Leakage from the pressurizer safety valves is collected in the effluent condensing tank (PR-T1) and the hydrogen is subsequently vented to the WL system. The leakage from the charge pumps is collected in the leak tanks located in each charge room, where it is eventually drained to inner bottom tank (PD-T5 or PD-T6) in the PD system. The inner bottom tanks are vented to the WL system.

The three explosive gas analyzers are routinely calibrated with two reference gases. One reference gas is pure air containing no hydrogen and is used to check the zero reading on the meter. The second reference gas is a mixture of 4% hydrogen (by volume) in air and is used to calibrate and check the full scale reading of the meter. Logged data for the analyzers indicate that detectable hydrogen concentrations have never occurred in the areas monitored.

9.2.4. Primary Relief System

9.2.4.1. Function

The primary relief system (PR system) prevents pressures in the primary system, steam generators, and PP system from exceeding the design code allowable pressures.

Additionally, the PR system provides a means of collecting and condensing effluent from the relief valves.

9.2.4.2. Description

The PR system, as shown in Drawing PR 18-J-376 consists of:

1. Safety and relief valves located on the steam generators (PR-12V, PR-14V, PR-16V, and PR-17V), the pressurizer (PR-1V, PR-3V, or PR-24V), the PP system let-down piping (PR-4V), and the effluent condensing tank (PR-7V).

2. Heat exchangers (PR-C1 and PR-C2) to cool pressurizer steam which may be leaking through the safety valves.

3. An effluent condensing tank (PR-T1), partially filled with water, to receive and condense the discharge from the pressurizer safety valves or to receive the discharge from the PP system relief valve.

The effluent condensing tank is a horizontal cylindrical tank with elliptical heads. The overall dimensions are 6 feet 8 inches long by 4 feet in diameter. It is constructed of carbon steel, and the inside is lined with a baked phenolic resin coating to retard corrosion. The tank contains six sparger mixers inside the tank on the influent line to provide better mixing of the influent with the water in the tank. Mixing promotes quicker condensation of steam in the influent. The tank has a 75 cubic foot volume of which 60 cubic feet is normally occupied by water and 15 cubic feet is occupied by gas. The design pressure is 100 psig.

9.2.4.3. Operation and Control

The pilot operated relief valve and the two safety valves for the pressurizer are discussed in Section 7. A low pressure rupture disc (PR-F11), set to relieve at 113 psig, is located on the main discharge line of the pressurizer safety valves downstream of the junction of the diaphragm valve and the spring-loaded valve lines. Two small heat exchangers, connected in parallel, are located on bypass lines around the rupture disc in the main discharge line. The heat exchangers cool steam that intermittently leaks through the safety valves. Cooling water for the heat exchangers is supplied from the intermediate cooling water system (CW system). If a safety valve opens, the rupture disc will burst allowing the relieved fluid to flow directly into the effluent condensing tank. A check valve (PR-6V) prevents backflow from the effluent condensing tank to the relief valves.

The two safety valves on each steam generator drum in the secondary system are set to relieve at 800 psig, the design pressure of the drums. The combined capacity of the valves on each drum is 108,000 pounds per hour. Low pressure rupture discs (PR-F4, PR-F6, PR-F7, and PR-F9), set to relieve at 16 psig, are installed at the end of the discharge piping. The rupture discs prevent intermittent steam leakage into the containment vessel. A small drain pipe, located between each safety valve and its rupture disc, conveys valve leakage to the containment drain tank (PD-T4). Each drain line contains a ball check valve (PR-18V, PR-20V, PR-21V, or PR-23V) to prevent the loss of both rupture discs if only one of the two relief valves on a steam drum opens.

A relief valve is located on the PP system just downstream of the flow control valves. The relief valve prevents excessive pressures in the low pressure piping and equipment (186 psig design) of the purification system. The relief valve is set to open at 150 psig and has a capacity of 75 gpm of water. The effluent is piped to the effluent condensing tank because the water is potentially radioactive. A check valve (PR-5V) prevents backflow from the tank to the relief valve.

The effluent condensing tank receives the discharge from the primary system relief valves. The tank pressure is relieved to the containment by a spring-loaded, self-actuated safety valve (PR-7V) set at 50 psig. The water level in the effluent condensing tank is maintained by draining excess water or by adding makeup water. Excess water is drained to the lab waste tank (PD-T1) through a diaphragm operated valve (PD-39V) which is operated at the sampling room instrument panel. The drain line is located on the side of the effluent condensing tank at the same elevation as the normal water level such that the water cannot be drained below this point. Makeup water for the effluent condensing tank is supplied from the CW system through a manual valve (CW-4V) located in the engine room. A tank level indicator is located near the valve so that the level can be monitored while the additions are being made. Gases in the effluent condensing tank are vented to the WL system through a diaphragm operated valve (PR-9V) located at the top of the tank.

Pressure, level, and temperature instrumentation is provided for the tank. Pressure is detected with a bourdon tube pressure gage (PIA/PR-1) and is transmitted to the main control console where the signal is used for an indicator on the main control console and for a high pressure alarm on the annunciator panel. The temperature is sensed with a resistance temperature element (TIA/PR-3) enclosed in a thermowell. The temperature is transmitted to the control room for indication on the main control console and monitoring and logging by the DA system. The tank level is measured with a differential pressure cell (LIA/PR-2) connected to a standpipe on the tank. The detected level is transmitted electrically to the main control room where the signal is:

1. Displayed on the main control console.
2. Monitored and logged by the DA system.
3. Monitored for high and low level alarms on the annunciator panel.

The tank level is also displayed on instrument (LI/PR-2) near the makeup valve (CW-4V) in the engine room.

9.2.4.3. Tests and Performance

The pressurizer and steam generator spring-loaded, self-actuated safety valves are shop tested annually in accordance with the USCG requirements. The set point and blowdown characteristics are checked in the test. All other relief valves in the PR system are tested annually in place.

Intermittent leakage is experienced from the spring-loaded pressurizer safety valves and from the pilot-operated pressurizer relief valve and its associated stop valve. The primary system fresh makeup water requirements and the quantity of waste water handled are affected by this leakage. Leakage is now reduced because of improvements in the valve design and maintenance procedures.

9.2.5. Primary Sampling System

9.2.5.1. Function

The SA system has the following general functions:

1. To supply representative primary water samples for analysis.
2. To supply representative samples for analysis of dissolved hydrogen and other dissolved gases in the primary water.
3. To provide a means of continuously monitoring the effectiveness of the PP system demineralizers.
4. To supply liquid samples of the drainage collected in the lab waste tank, the makeup storage tanks, and the inner bottom tanks for analysis.

9.2.5.2. Description and Operation

The SA system (see Drawing SA 24-J-383) consists of the following:

1. A loop in which water is taken from and returned to the PP system at points upstream of the demineralizers.
2. A loop in which water is taken from a point downstream of the PP system demineralizers and returned to the buffer seal surge tank.

The second loop is also used to sample the lab waste tank (PD-T1), the inner bottom tanks (PD-T5 and PD-T6), and to provide samples for analyses of dissolved gases in the primary water. A third arrangement is provided for sampling the makeup storage tanks (PD-T2 and PD-T3).

The sampling hood is a combined hood and sink, which form a unit about 8 feet high, 5 feet wide, and 3 feet deep. The opening in the hood is normally covered with a sliding glass panel. A faucet from the ship's fresh water supply is provided to wash the sink after spillage of sample water. The sink drains to inner bottom tank PD-T6. The hood is vented through a flame arrestor (WL-F3) to the suction of the RSV system fans (RS-P1 and RS-P2).

The first sampling loop is connected to the PP system downstream of the letdown coolers. Block orifices (SA-F3 and SA-F10) regulate the flow and pressure in the sampling loop. Diaphragm operated stop valves (SA-1V and SA-4V), located upstream and downstream of the orifices, isolate the sampling loop.

A relief valve (SA-17V, set at 100 psig) is located on the loop line between valve SA-1V and the containment penetration. The relief valve is provided to protect the low pressure piping located downstream of valve SA-1V and discharges to the containment drain tank (PD-T4).

A pressure switch (PA/SA-1) is connected to the sampling line just outside of the containment. This switch actuates when high pressure exists in the line, and the resultant electrical signal is fed to the annunciator panel in the main control room. A diaphragm operated valve (SA-45V), located downstream of the pressure switch, isolates the loop if a pressure increase occurs inside the containment vessel. The loop is then routed through the secondary shield to the sampling room which is located above the forward area of the secondary shield at the D-deck level.

In the sampling room, a conductivity cell (CIRA/SA-6) and a pH cell (pHI/SA-8) are connected to the loop. They monitor the water quality of the purification demineralizer influent which is essentially the same as the primary system water quality. The conductivity cell consists of a measuring electrode, a reference electrode, and a temperature compensator. The conductivity and pH measurements are displayed on the sampling room instrument panel and on the main control console. A high conductivity is alarmed on the annunciator panel.

Flow through the sampling loop is controlled by a manual control valve (SA-3V) located outside the sampling hood. When samples are not being taken loop flow is about 1 gpm. The flow is measured by a direct indicating rotometer (SA-4). Samples can be taken from this loop either in a sample bomb or from a faucet (SA-108V). The sample bomb is located in a bypass line around flow control valve (SA-3V). The sampling bomb bypass line contains a rotometer (SA-2), double isolation valves (SA-8V, SA-9V, SA-25V, and SA-27V), and disconnect joints (SA-5 and SA-6) to permit sampling at the sample loop pressure.

The second sampling loop is similar in arrangement to the first loop. It is connected to the PP system downstream of demineralizers. A diaphragm operated isolation valve (SA-19V) is located near the PP system connection and is actuated by pushbuttons on the sampling room instrument panel. The loop contains a conductivity cell (CIRA/SA-7), which monitors the water quality of the demineralizer effluent. The water can flow through the sampling bomb line inside the hood or through the bypass line. Flow through the loop is controlled by a manual control valve (SA-15V) located outside the hood. Rotometers (SA-3 and SA-5), downstream of the sampling bomb and bypass line, are used to adjust the loop flow. The normal flow is about 1 gpm. The water is returned to the buffer seal surge tank. A diaphragm operated valve (SA-32V), actuated with the same pushbuttons as used for valve SA-19V, is located near the connection to the surge tank.

Samples for dissolved hydrogen and total gas analysis are taken upstream of the sample bomb. A water faucet is also located upstream of the sample bomb so that bottle samples can be taken. Locally indicating bourdon tube type pressure gages (PI/SA-10 and PI/SA-12) are located on each side of the sampling bomb. A pressure indicator (PI/SL-7) for the buffer seal surge tank (SL-T1) is also located inside the hood so that the tank pressure can be monitored while samples are taken.

The second sample loop is arranged so that it can be used to sample the lab waste tank (PD-T1) and the inner bottom tanks (PD-T5 and PD-T6) in the PD system. To perform this function a supply line is connected between the discharge header for the waste transfer pump (PD-P1) and the upstream side of the sampling bomb. A return line is located between the downstream of the bomb and the suction header for pump PD-P1. Diaphragm operated isolation valves are located on the supply line (SA-24V) and in the return line (SA-29V). Both valves are actuated with the same set of pushbuttons on the sampling room instrument panel. The pushbuttons for valves SA-19V and SA-32V and the pushbuttons for valves SA-24V and SA-29V have an electrical interlock arrangement so that one set of valves cannot be opened when the other set of valves are open. This minimizes the possibility of contaminating primary water with water from the waste storage tanks.

The manual valving for the lab waste tank and the inner bottom tanks is arranged so that the inlet and outlet lines can be connected to pump PD-P1 to circulate a representative sample through the sample bomb for subsequent analyses. The valves have reach rods which are operated in the sampling room.

Makeup storage tanks PD-T2 and PD-T3 can be sampled with the same arrangement provided for tanks PD-T1, PD-T5, and PD-T6; however, a direct line runs from the primary makeup pump (PD-P2) discharge line to a water faucet in the sampling hood. This line is used to sample the primary system expansion water stored in these two tanks.

9.2.5.3. Tests and Performance

The frequency of sampling with the SA system depends on the mode of plant operations. The demineralizer influent (primary system water) and effluent are sampled on a scheduled basis. The lab waste tank and the inner bottom tanks are sampled prior to transfer of the tank contents overboard or to dockside for storage. Tanks PD-T2 and PD-T3 are sampled when expansion water is being added to the primary system. The samples are collected in plastic bottles at the three water faucets inside the sampling hood since the low activity of the water does not create a radiation hazard when the samples are taken. The samples are transported to the chemical laboratory on the port side of the main control room for the analysis.

9.2.6. Intermediate Cooling System

9.2.6.1. Function

The CW system cools various components in the reactor plant while maintaining an intermediate barrier between primary water and sea water. This minimizes the possibility of releasing radioactive fluid directly to the sea and minimizes the possibility of water containing chlorides contacting equipment constructed of stainless steel.

9.2.6.2. Description

The CW system (see Drawing CW 47-J-394) has two separate flow circuits, one for sea water and one for fresh water. The sea water circuit is composed of two pumps (CW-P1 and CW-P2), two main intermediate coolers (CW-C1 and CW-C2), a suction sea chest, an overboard discharge, manual valves, and piping. The two pumps are arranged in parallel with one as standby. The coolers are connected in parallel so that either pump can deliver sea water to either cooler. The sea water pumps take suction from the sea chest and pump the sea water to the tube side of the intermediate coolers. Heat is removed from the fresh water circulating through the shell side. The heated sea water is then discharged through the overboard discharge. The intake for the pumps is also connected to the suction sea chest for the salt water service system. This sea chest can be used if the normal sea chest is clogged or out of service. An auxiliary overboard discharge is also provided. Additionally, the salt water circuit normally supplies cooling water for reactor space cooling coils (RS-C1 and RS-C2). The line is connected to the discharge of the sea water pumps.

The sea water pumps, located at the forward end of the engine room on the lower level, are vertically mounted centrifugal pumps of bronze construction. They have a design rating of 1491 gpm with a suction head of 4 to 9 psig and a total developed head of 20 psi. The motor is rated at 25 horsepower.

The fresh water circuit is a closed loop consisting of two circulating pumps (CW-P3 and CW-P4), two main intermediate coolers (CW-C1 and CW-C2), a surge tank (CW-T1), manual valves, a strainer (CW-F26), control valves, relief valves, instrumentation, and piping. The pumps circulate fresh water through the shell side of the intermediate coolers to a supply header. Fresh water flows from this header to the components to be cooled as follows:

<u>Components Inside the Containment</u>

1. Purification letdown coolers (PP-C1, PP-C2, PP-C3, and PP-C4).
2. Neutron shield tank cooling coils (CW-F12 and CW-F13).
3. Primary relief valve leakoff condensers (PR-C1 and PR-C2).
4. Containment air cooling coils (CC-C1 and CC-C2).
5. Primary pumps (PS-P1, PS-P2, PS-P3, and PS-P4).

<u>Components Outside the Containment</u>

1. Buffer seal coolers (SL-C1 and SL-C2).
2. Control rod drive hydraulic power supply coolers 1 and 2.
3. Instrument air compressors (NI-P1 and NI-P2) and associated after coolers.
4. Quantichem analyzer coolers.
5. Feedwater sample cooler.

The water from these components collects in a return header and then completes the cycle by flowing through a common line to the suction of the fresh water circulating pumps. The fresh water pumps (CW-P3 and CW-P4) are arranged in parallel with one acting as a standby. They are vertically mounted centrifugal pumps made of bronze. The design flow rate for each pump is 675 gpm with a suction head of 15 psig and with a total developed head of 65 psi. The fresh water pumps are located at the forward end of the engine room on the lower level.

Downstream of the fresh water pumps, the intermediate coolers (CW-C1 and CW-C2) are arranged in parallel so that either pump can be used with either cooler. The coolers are single-pass, straight, shell-and-tube heat exchangers with salt water flowing through the tubes and fresh water flowing through the shell side. The tubes, associated tube sheet liners, and inlet and outlet plenums are 70-30 copper nickel; the shell is carbon steel. The normal heat load handled by a cooler is about 6.02×10^6 Btu/hr; however, each cooler has sufficient reserve capacity for operations such as increased flow rates through the PP system. The design heat load for each cooler is 15.7×10^6 Btu/hr. This heat load is based on fresh water entering at 143 F and leaving at 95 F while the sea water is heated from 85 F to 106 F. The coolers are mounted on the forward bulkhead of the engine room near the lower level. Each cooler is about 19-1/2 feet long by 20 inches in diameter.

The following components are located in the common outlet line for the coolers:

1. Strainer (CW-F26).
2. Diaphragm-operated valve (CW-29V).
3. Pressure detector for instrument PICA/CW-7.
4. Temperature detector for instrument TIA/CW-5.
5. Flow nozzle for instrument FI/CW-6.

The strainer is a duplex unit, which filters suspended matter from the fresh water coolant stream. One strainer is normally in operation. If the operating strainer becomes clogged, a built-in switching arrangement is used to change to the other strainer. The clogged strainer can be removed for subsequent cleaning.

From the flow nozzle the fresh water enters the supply header to the components being cooled. Each set of purification letdown coolers has an individual supply line from the header in the engine room to the units inside the containment. A manual isolation valve is located in each supply line in the engine room. A check valve is located in each supply line inside the secondary shield area to prevent backflow. The fresh water flows in parallel through the two coolers in each set. The flow in the coolers is on the shell side. The cooling water leaving each set of coolers is collected in one return line. Each pair of coolers has a relief valve set at 150 psig (valve CW-93V and CW-92V). These relief valves are located on the return line for each pair of coolers. The relief valves prevent excessive pressures in the lines and in the shell side of the coolers in the event a tube should leak or rupture. The relief valves discharge to the containment. Inside the secondary shield area, the two return lines contain stop check valves and diaphragm-operated valves (CW-201V and CW-202V), which are actuated by the containment isolation system. Downstream of the stop check valves the two return lines connect into a common line, which is routed to the main return header in the engine room. On the return line in the engine room, a diaphragm-operated valve (CW-39V) controls the cooling water flow through the operating set of coolers. This valve is automatically controlled by a temperature monitor (TICA-PP4) of the primary water leaving the coolers. Valve CW-39V can also be controlled by remote manual means with a manual loader on the main console. A bypass line containing a manual valve (CW-140V) is provided around valve CW-39V for controlling the cooling in the event valve CW-39V is inoperative.

Individual supply lines are provided for cooling the neutron shield tank cooling coils, which are located in the neutron shield tank surrounding the reactor vessel. Each supply line contains a manual isolation valve near the supply header in the engine room. A check valve is located in each line inside the secondary shield area to prevent backflow. Relief valves (CW-196V and CW-194V) set at 150 psig are located on the supply lines to prevent overpressure in the event the temperature of the water in an isolated circuit should increase and cause the water to expand. Inside the secondary shield area, the individual return lines contain stop check valves. The return lines join a common line, which is routed to the return header in the engine room. Inside the secondary shield area, a diaphragm-operated valve (CW-203V) is operated by the containment isolation system. Near the return header in the engine room, the return line contains a manual isolation valve and a manual control valve.

The cooling water lines for primary relief valve leakoff condensers (PR-C1 and PR-C2) are connected to the return line for neutron shield tank cooling coil CW-F12. The return line for the neutron shield tank coil contains a manual valve (CW-217V), which is normally closed so that all of the flow through the coil is through the leakoff condensers. The condensers have isolation valves on the inlet and outlet lines.

Individual supply lines and return lines are provided for containment air cooling coils (CC-C1 and CC-C2). A manual isolation valve is provided for each supply and return line in the engine room near the headers. Inside the secondary shield area, a check valve is located on each supply line to prevent backflow. Relief valves (CW-190V and CW-192V) are set at 150 psig and are located inside the containment vessel. These relief valves are provided on the supply lines to prevent overpressures in the event the temperature in an isolated circuit should increase and cause the water to expand.

The CW system water removes the heat from the motors and the bearings of the primary pumps. The cooling water flows through a jacket surrounding the motor section of the pump, and primary water in the pump motor cavity flows through a coil in this jacket. Each pump has a separate supply and return line connected to the main headers. A manual isolation valve is located on each supply and return line near the headers in the engine room. A manual control valve is also located on each return line in the engine room. Supply lines contain check valves inside the secondary shield area to prevent backflow. Relief valves (CW-50V, CW-54V, CW-58V, and CW-64V) are located on the supply lines. These relief valves are near the pumps inside the containment and are set for 150 psig. These valves prevent excessive pressure in the cooling lines and pump cooling jacket if the primary water coil in the jacket should rupture and cause primary water to leak into the CW system water. These relief valves discharge to the containment vessel.

Common supply and return lines are provided from the main headers in the engine room to the buffer seal coolers (SL-C1 and SL-C2) in the port stabilizer room. Manual isolation valves are provided on the upstream and downstream sides of each cooler. In the coolers, the cooling water flows through the shell side while the primary or seal return water flows through the tube side.

Common supply and return lines are routed to the three hydraulic power supply coolers in the hydraulic equipment room located on the starboard side of the reactor compartment at B-deck level. These coolers are used to cool the hydraulic fluid associated with the operation of the control rod drives. Flow through each cooler is controlled by manual valves (CW-142V and CW-143V) located at the coolers. Relief valves (CW-235V and CW-236V set at 150 psig) on the return cooling lines prevent excessive pressures in the coolers and associated piping.

The CW system water to the instrument air compressors and their after coolers is controlled by valve CW-240V, which maintains the pressure downstream at 45 psig.

Fresh water from the CW system is supplied to three coolers (QC-C1, QC-C2, and QC-C3) associated with the Quantichem analyzer, which monitors the cooled samples of water for chloride content. The feedwater sample cooler, which cools samples of feedwater in the steam plant, is also supplied by the CW system. This equipment is located in the engine room.

In addition to its cooling functions, the fresh water supply header is used to supply fresh makeup to effluent condensing tank (PR-T1) and to the neutron shield tank surrounding the reactor vessel. Both tanks are located inside the containment. The additions to the effluent condensing tank are made with manual control valve (CW-4V) located on the makeup line in the engine room.

The cooling water collected in the main return header is routed to the suction side of the fresh water pumps (CW-P3 and CW-P4). A surge tank (CW-T1) is connected by a standpipe to the suction line for the pumps. This surge tank is located at B-deck level on the port side and aft end of the reactor compartment. The tank provides for thermal expansion and contraction of the fresh water in the closed loop. Its elevated position also provides a net positive suction pressure for the fresh water pumps. The tank has a volume of 26.7 cubic feet and is constructed of carbon steel. A gage glass, located on the side of the tank, is used to monitor the level locally. Two pressure switches (LA/CW-1) connected to the tank transmit electrical signals to the main control room to provide for high and low level alarms on the annunciator panel. Fresh makeup to the tank is provided by a manual makeup line or by an automatic float valve (CW-90V). The makeup is normally supplied from the combined discharge of the condensate pumps in the condensate system. Control chemicals can be added through a funnel connected to the top of the tank. An auxiliary makeup line for the tank is connected to the discharge of the port feed pump. The makeup enters the tank through the chemical feed funnel. A vacuum breaker (CW-158V) set at 5 inches of mercury prevents a vacuum in the tank. An overflow line connects to the top of the tank and drains to the bilge. A recirculation line is connected between the discharge of the fresh water pumps and the top of the tank. This arrangement permits recirculating the tank contents if control chemicals are added.

9.2.6.3. Operation and Control

The sea water pumps may be operated with pushbuttons on the main control console or with pushbuttons near the pumps. A locally indicating, bourdon tube pressure gage is provided at the discharge for each sea water pump and at the common discharge header. The pressure in the common discharge header is detected with a bourdon tube (PT PN 28), and the detected pressure is transmitted pneumatically to the main control room for indication on the main console. Locally indicating mercury thermometers are located on the salt water inlet and outlet lines for each intermediate cooler.

The fresh water pumps may be operated with pushbuttons located near the pumps. Locally-indicating bourdon tube pressure gages are located on the common suction and discharge headers for the fresh water pumps.

A diaphragm-operated valve (CW-29V) is used to automatically maintain a relatively constant supply pressure of about 55 psig for the individual fresh cooling water circuits. The pressure is directly detected downstream of the valve by the bourdon tube associated with instrument PICA/CW-7. The detected pressure is transmitted pneumatically to the main control room, where it is used for:

1. Indication on the main control console.
2. High- and low-pressure alarms on the annunciator panel.
3. Pressure monitoring and logging (normal, high alarm and low alarm pressures) with the DA system.
4. Automatic control of valve CW-29V at the main control console. In addition to the automatic control feature, valve CW-29V can be controlled on the main control console with a manual loader.

The temperature in the common heat exchanger outlet line is sensed with a gas bulb detector (TIA/CW-5). The detected temperature is transmitted by pneumatic signals to the main control room, where the following are provided:

1. Temperature indication on the main control console.
2. High-temperature alarm on the annunciator panel.
3. Temperature monitoring and logging (both normal and high-alarm temperatures) with the DA system.

The flow through the flow nozzle (F1/CW-6) in the main fresh water stream from the heat exchangers is detected with a differential pressure cell. The detected flow is transmitted by a pneumatic signal to the main control room, where the signal is used for flow indication on the main control console.

Proper operation of the coils in the neutron shield tank is monitored with neutron shield tank temperature indicator TIA/SW-2 on the main control console. The temperature is also monitored and logged by the DA system. Normally, both coils are in operation.

The return lines from the containment cooling coils have diaphragm-operated valves (CW-205V and CW-206V), which are operated by the containment isolation system if a pressure buildup occurs in the containment vessel. Flow through the coils is controlled with manual valves on the return lines in the engine room. The performance of the coils is monitored with containment air temperature instrumentation in the CC system. Normally, both cooling coils are in operation.

The containment air cooling unit is arranged so that it can be used to cool the containment vessel atmosphere in the event of a temperature and pressure buildup following an accident such as an MCA. Since there is a possibility that one of these coils or lines inside the containment may rupture during such an accident, an arrangement is provided so that the integrity of the coils and lines can be determined before the air-conditioning unit is placed into operation. This procedure is generally as follows. As a result of the containment vessel pressure increase, containment isolation valves (CW-205V and CW-206V) have closed. The manual isolation valves on the CW system supply lines to all equipment, except the containment cooling coils, within the containment vessel are closed. The outlet valves (CW-152V and CW-153V) from the containment cooling coils are closed and the CW system and surge tank (CW-T1) level are monitored for indications of loss of integrity of the coils.

Each return line from the primary pumps contains a diaphragm-operated isolation valve (CW-207V, CW-208V, CW-209V, or CW-2010V) which is operated by the containment isolation system. Each return line also contains a flow orifice (FA-CW8, FA-CW9, FA-CW10, or FA-CW11). These isolation valves and flow orifices are located inside the secondary shield area. Low flow through the orifice is detected with a differential pressure switch arrangement. The detected low flow is transmitted by electrical signals to the main console, where the signals provide for a low-flow alarm on the alarm annunciator panel. This instrumentation is provided to ensure that adequate cooling water flow is supplied to the pumps.

A diaphragm-operated valve (CW-129V) on the return line from the buffer seal coolers is used to control the cooling water flow. This valve is controlled by a manual loader on the main control console. The performance of the coolers is monitored with instrument TIA/SL-11 in the SL system. A bypass line containing manual valve CW-155V is located around valve CW-129V so that the cooling water flow can be adjusted manually if valve CW-129V is inoperative.

Two relief valves (CW-233V and 234V) are set at 150 psig and are provided on the cooling water outlet lines from the coolers to prevent excessive pressures. The relief valves discharge to the port stabilizer room.

The level in the effluent condensing tank is monitored with a level indicator (LI/PR-2 in the PR system) located near the makeup valve. Additions of water to the neutron shield tank are made with a manual control valve (CW-42V) on the makeup line in the engine room. Inside the secondary shield, both makeup lines contain check valves to prevent backflow.

9.2.7. Containment Cooling System

9.2.7.1. Function

The containment cooling system (CC system) maintains the air in the containment vessel at proper conditions in order to prevent deterioration of electrical equipment and instrumentation. The system is also arranged to cool the containment vessel atmosphere in the event of a temperature and pressure increase following an MCA.

9.2.7.2. Description

The CC system is designed to maintain the air in the containment at an average temperature of 128 F and an average relative humidity of 58%. These averages are obtained with air in the upper part of the containment at 140 F and approximately 44% relative humidity and with air in the lower portion of the containment at 115 F and approximately 80% relative humidity. The system is designed to remove 300,000 Btu/hr sensible heat and 177,000 Btu/hr latent heat to maintain these conditions. The sensible heat is transferred to the air from the hot surfaces of the equipment in the containment, and the latent heat results from leakage of water into the containment air. As shown in Drawing CC 49-J-402, the CC system consists of inlet and outlet air ducts and a main air-conditioning unit. The two main inlet air ducts in the upper part of the containment vessel extend in the fore and aft direction between the reactor vessel and the steam generators. Two branch inlet ducts also draw air from the dome section of the containment vessel, where the control rod drive structure is located. The air-conditioning unit is made up of a casing surrounding three air cooling coils (CC-C1, CC-C2, and DK-C2), one manually operated bypass damper (CC-F5), two circulating fans (CC-P1 and CC-P2), two outlet dampers (CC-F29 and CC-F30), and a mixing chamber. The unit is located at the aft end of the containment vessel. The two main outlet air ducts in the lower part of the containment vessel extend in the fore and aft direction on each side of the reactor vessel. A branch outlet duct is routed to the bottom of the pressurizer to cool the cables for the pressurizer heaters.

The fans (CC-P1 and CC-P2) pull air into the inlet ducts from the top of the containment vessel and the cupola dome space. The inlet air flow is controlled by the air registers located in the main and branch ducts. The vanes on the registers are manually adjustable. The air is directed through the ducts down towards the main air-conditioning unit, where it passes over the coils, and a small portion is bypassed. The air that is bypassed around the coils is mixed with the air leaving the coils in the mixing chamber before entering the fans. A manually adjustable damper controls the bypass flow. The fans discharge the air into the outlet ducts at the bottom of the containment vessel. Air grills located along the outlet ducts and the branch duct distribute the air throughout the bottom of the containment vessel. The vanes on the grills are manually adjustable.

Two of the coils (CC-C1 and CC-C2) are in the CC system, and the third coil (DK-C2) is in the DK system. The two containment cooling coils are fin tubes, constructed of 70-30 copper nickel. They are cooled with water from the CW system. Each coil is designed to handle the total heat design load of 477,000 Btu/hr. Normally, both coils are used. If one coil should leak, it could be isolated, and the other coil would remove the total heat load from the air. The cooling water flow to the coils is controlled by manual valves (CW-152V and CW-153V) located in the engine room.

The DK system cooling coil is similar to the other two coils. It is constructed of 90-10 copper nickel and is cooled by sea water. This coil has a design heat load rating of 400,000 Btu/hr.

Directly below the cooling coils in the main unit is located a set of V-type troughs. These troughs collect moisture condensed by the coils. The troughs drain to a catch pan, which in turn is drained to the containment drain tank (PD-T4).

The two fans in the air-conditioning unit have motors with two-speed windings. During normal plant operations one of the fans is operated at the high speed. The half-speed feature is provided to permit operation of the fans in the dense atmosphere, with air pressure up to 60 psig, that exists during containment leak rate tests and higher pressures and temperatures that may follow an MCA. This arrangement for the cooling coils provides a means for reducing the pressure and temperature inside the containment after an accident. At full speed the fans have a design rating of 11,000 cfm each, and at half speed the design rating is 5500 cfm each in a 100 psi steam atmosphere. Each motor has a design rating of 10 hp at full speed and 2.8 hp at half speed. The fans can be manually switched from off to low speed or high speed with pushbuttons on the main control console. Since the fans are operated during an emergency cooling situation, they can be operated in the same manner from the emergency cooling panel on the navigation deck.

A damper is located at the discharge of each fan. The air pressure developed by the operating fan closes the damper on the discharge of the idle fan. Lights are provided on the main control console to indicate the position of the dampers.

Since there is the remote possibility that the two main outlet ducts might become flooded following an MCA, emergency vent openings are located in the main duct work just below the fans. The cover plates are held in place with 160 F fusible links.

9.2.7.3. Operation and Control

Resistance temperature elements are located at five different places in the containment vessel as follows:

1. Inside the outlet air duct (TI/CC-5).
2. In the bottom of the containment vessel (TI/CC-4).
3. In the upper portion of the containment vessel on the port side (TI/CC-3).
4. In the upper portion of the containment vessel on the starboard side (TI/CC-2).
5. In the cupola dome near the control rod drives (TIA/CC-1).

In addition, a resistance temperature element, which detects the wet bulb temperature, is located in the main outlet duct near the temperature element that measures the dry bulb temperature. All of the wet and dry bulb temperatures are transmitted by electrical signals to the main control room, where they are monitored and logged by the DA system. The signal from the temperature element in the cupola is used for high-temperature alarm monitoring and logging with the DA system.

Two detectors are provided for detecting the pressure in the containment. One (PIA/CC-7) is used for low-range pressure measurements so that small changes in containment pressure can be monitored. The other one (PI/CC-6) is used for high-range pressure measurements up to the design pressure (186 psig) of the vessel. The low-range detector senses the pressure (0 to 15 psig) with a bellows arrangement, and the high-range detector senses the pressure (0 to 200 psig) with a bourdon tube. Both detected pressures are transmitted by pneumatic signals to the main control console. The low-range pressure signal is used for indication on the main control console and for a high-pressure alarm on the annunciator panel. The high-range pressure signal is also for indication on the main control console as well as for monitoring and logging of the pressure (both normal-pressure and high-pressure alarm point) with the DA system. Since there is a possibility that the bellows in the low-range instrument may rupture if there is a significant pressure buildup in the containment, a solenoid isolation valve is located in the detecting line to the bellows. The solenoid valve is actuated by a pressure switch connected to the solenoid valve, and the valve closes to isolate the line when the containment pressure increases to 14 psig.

Three pressure switches (PC/CC-8) are also connected to the containment pressure detecting line. These switches provide signals for the actuation of the containment isolation system if a pressure buildup occurs.

9.2.7.4. Tests and Performance

This system operates during all phases of plant operations. Since the operation of the DK system is checked on a weekly basis, the related operations of this system are also checked at the same time. The fans have operated satisfactorily at low speed during containment vessel leak rate tests at pressures up to 60 psig. This indicates that the fans should be capable of operating at half speed in the dense atmosphere that may exist following an MCA.

During normal operations the performance of this system has been generally satisfactory. The temperatures inside the containment have been within the desired ranges. The relative humidity in the containment vessel is normally below 40%. On a few occasions, increases in relative humidity have been noted; these were found to be related to minor leaks in small lines which connect with the secondary side of the steam generators. After these leaks were repaired, the relative humidity returned to normal.

9.2.8. Shutdown Circulation System

9.2.8.1. Function

When the primary system is cool and completely depressurized for refueling or other maintenance purposes, flow cannot be maintained to remove decay heat from the core because there is insufficient pressure to satisfy the net positive suction head of the primary pumps. As a consequence, a temporary shutdown circulation system is provided to operate in association with the letdown coolers in the PP system to remove the decay heat during this situation.

9.2.8.2. Description

As shown on Drawing PS 09-F-745, the shutdown circulation system consists of a circulating pump (SC-P1), a filter (SC-E1), pressure gages, a flow indicator (SC-F1), valves, and piping. The suction side of the pump is connected to the PP system piping at a point between the letdown coolers and the flow control valves. The pump discharges through a Rotameter and filter to the makeup line in the SL system, which connects to the body of the gate valve in the reactor return line for the starboard loop. Therefore, when this system is operated, the pump draws primary water from the reactor outlet line for the port loop down through the letdown coolers and returns the water to the reactor inlet line for the starboard loop. The core is cooled by natural circulation in the reactor vessel, and the decay heat is dissipated to the CW system water through the letdown coolers. The port and starboard loops are isolated by gate valves when this system is being operated.

9.2.8.3 Operation and Control

Two pressure gages, one on the pump suction and one on the pump discharge, along with the Rotameter on the pump discharge, are used to monitor the operation of this system. A low-flow alarm, operated by the Rotameter, is provided in the main control room. The temperature of the primary water leaving the reactor vessel is also monitored in the main control room.

Since the shutdown circulation system is designed for low pressure and connects to the high-pressure portions of the SL and PP systems, flanges are provided on each side of the loop so that the system can be blanked off when it is not in operation.

9.2.8.4 Testing

Tests and operation, especially during the core shuffle outage, have shown that the system will circulate adequate flow through the letdown coolers to remove the decay heat and to maintain the primary water at less than 150F.

9.2.9 Primary Pressurizing System

9.2.91. Function

The primary pressurizing system (PE system) serves to:

1. Maintain the required primary system pressure to keep the primary coolant in the liquid state.

2. Limit pressure fluctuation caused by thermal expansion and contraction of the primary coolant during power plant load transients.

3. Accommodate the necessary safety valves to prevent the primary system from being overpressurized.

4. Maintain the amount of coolant in the primary system within specified levels.

9.2.9.2 Description

The details of the pressurizer are discussed in section 7.4 (see Drawing PE 15-J-405). The PE system consists mainly of the instrumentation and controls and associated valves and piping used to perform the system functions described above.

9.2.9.3. Operation and Control

The pressure in the steam space of the pressurizer is detected by two separate electrical transmitters (LICRA/PE-2) using bourdon tube arrangements connected directly to the vessel. Two detector arrangements are provided to make the instrumentation more reliable. The two electrical signals are individually transmitted to a pressure recorder on the left side of the main control console in the main control room, where both the pressure measurements are recorded. The signals are then converted to pneumatic signals and are transmitted to a selector switch on the main control console, where either signal may be selected for:

1. A wide-range pressure indicator on the main control console.
2. A narrow-range pressure indicator on the main control console.
3. A controller on the main control console for automatically controlling spray valve (PE-IV or PE-3V).
4. Automatic sequential operation of the pressurizer heater banks.
5. High- and low-pressure alarms on the annunciator panel.
6. A controller on the main control console for the automatic operation of diaphragm-operated relief valve PR-3V.
7. Monitoring and logging of normal temperatures and high- and low-pressure alarms in the DA system.
8. High- and low-pressure scrams associated with the safety system.

The 160 electric heaters in the bottom head of the pressurizer are connected in five groups of 12, 12, 24, 40, and 72 units. These groups can be automatically controlled in successive steps by the pressurizer instrumentation as the pressure is reduced during an outsurge. Normally, only one group of 12 units is required to maintain the pressure at 1750 psia during steady state operation. A control switch is provided on the main control console for each group of electric heaters so that the heaters may be operated in the deenergized or automatic mode. In order to maintain a primary system overpressure during emergency cooling operations, the two groups of 12 heaters are arranged so that they can be operated from the emergency cooling panel in the emergency diesel generator room on the promenade deck.

Spray water is supplied to a nozzle inside the pressurizer with a line connected from the starboard loop reactor inlet line. Hence, the pressure drop across the reactor is used as the driving force for the spray. The two diaphragm-operated spray control valves (PE-1V and PE-2V) are connected in parallel in the line so that one acts as a standby. Normally, the spray valves are automatically operated by a signal from the pressure instrumentation, but the spray can also be operated by remote manual means from the main console. A diaphragm-operated stop valve (PE-2V) is located on the spray line upstream of the control valves and is controlled by pushbuttons on the main console. This valve is closed if the spray control valve fails to close. During an insurge into the pressurizer, the pressure instrumentation opens the spray valve so that the spray will condense the steam in the upper region and prevent an excessive pressure rise. However, if the pressure increase should be excessive, spring-loaded relief valve (PR-1V or PR-24V) would open to relieve the steam to the effluent condensing tank. The pilot-operated relief valve (PR-3V) is designed to open before the spring-loaded code valves to minimize the chance of weepage due to improper reseating of the spring-loaded valves. If the pilot-operated valve fails to function properly, then one of the spring-loaded safety valves will open to relieve the steam.

Two separate standpipe arrangements (LICA/PE-2) are provided in the pressurizer for measuring the level. A small line containing valve PE-9V and an orifice is connected from the spray line (downstream of valve PE-2V) to the top of the pressurizer so that a small amount of water flows into the reference cups associated with the standpipes. This water helps keep the reference legs for the standpipes filled. The level is detected by two electrical differential-pressure transmitters connected to the standpipes. Two detecting arrangements are provided for reliability. The level electrical signals are transmitted to separate selector or transfer switches on the emergency cooling panel in the emergency diesel room. The selector switches have two positions. One position is used to feed the signals to the instrumentation on the emergency cooling panel, and the other position is used to feed the signals to the main control room. When the switches are in the emergency cooling positions, the signals provide for level alarm annunciation on the emergency cooling panel. In the other selector switch positions, the signals are electrically transmitted to a level recorder, where both levels may be recorded. The signals are then converted to pneumatic signals and are transmitted to a selector station on the main control console, where either signal may be selected for:

1. A level indicator on the main control console.
2. High- and low-level alarms on the annunciator panel.
3. A controller on the main control console, which automatically controls makeup valve SL-121V in the SL system, which provides the makeup to the primary system.
4. A pressure switch which deenergizes the pressurizer heaters on a low pressurizer level to prevent the heaters from being damaged if they are uncovered.
5. Monitoring and logging of the normal level and high- and low-alarm levels by the DA system.

Two temperature resistance elements (TIRA/PE-3) are located in the pressurizer. One is located in the steam space, and the other is located in the water space. The electrical signals are transmitted to a recorder on the left side of the main control console, where both temperatures are recorded. The electrical signals are then retransmitted to a selector switch on the main control console, where either signal may be selected for:

1. A temperature indicator on the main control console.
2. A high-temperature alarm on the annunciator panel.
3. Monitoring and logging of the normal temperature and the high-alarm temperature with the DA system.

The temperature in the surge line between the pressurizer and the reactor outlet line is detected with a resistance temperature element located in a thermowell in the line. The electrical signal for the temperature is transmitted to the main control room, where it is used for indication on the main control console. This indication is used to determine whether the temperature in the surge line deviates significantly from that of the primary system.

Two venting arrangements are provided for the pressurizer. One line contains manual vent valves (WL-2V and WL-3V) and is routed to containment drain tank (PD-T4), which in turn is vented to the gas manifold in the WL system. Consequently, this vent line is used only when the containment vessel is accessible. The second vent line contains a diaphragm-operated valve (WL-1V) operated with push-buttons on the main control console. The second vent line is routed to the PP system at a point on the main line between the letdown coolers (PP-C1, PP-C2, PP-C3, and PP-C4) and the flow control valves (PP-6V, PP-7V and PP-8V). During heatup and power operations, the second vent line is used to purge the pressurizer steam space of noncondensable gases and gaseous fission products. The gases subsequently collect in the buffer seal surge tank (SL-T1).

9.3. Waste Management Systems

9.3.1. Equipment Drain and Waste Collection System

9.3.1.1. Function

The function of the equipment drain and waste collection system (PD system) is to drain and collect radioactive liquid wastes resulting from operation of the nuclear plant.

9.3.1.2. Description

The PD system flow sheet is shown on Drawing PD 31-J-396, and the routing of liquid drainage and storage are shown in Table 9-1.

Table 9-1. Liquid Drainage and Storage

Source	Bottom of containment	Containment drain tank PD-T4	Lab waste tank PD-T1	Forward drain well	Makeup storage tanks PD-T2 & PD-T3	Inner bottom tanks PD-T5 & PD-T6	Waste transfer pump PD-P1
Primary gate valve packing		X					
Containment cooling condensate		X					
Boiler relief valve leakage		X					
Sampling system relief valve leakage		X					
Reactor shield tank overflow	X						
Drain from control rod housing	X						
Valve packing leakage		X					
Effluent condensing tank			X				
Laboratory waste			X				
Purification system effluent filter backwash			X				
Intermediate cooling surge tank overflow			X				
Sampling sink drain						X	
Drain wells						X	
Containment vessel drain						X	
Intermediate cooling system drain						X	
Booster pump seal leakage				X			
Buffer seal surge tank drain					X		
Containment drain tank						X	
Buffer seal charge pump gland leakage						X	
Bilge water from port stabilizer room							X
Condensate from ventilation system				X			
Bilge water from charge pump rooms							X

9.3.1.3. Operation and Control

Liquid wastes stored in the system tanks are segregated as follows: liquids with a high solids content in the lab waste tank (PD-T1), primary system expansion water in the waste storage tanks (PD-T2 and PD-T3), and other liquid waste in the inner bottom tank (PD-T6). During primary system heatup the primary system water accumulated in the PD system is kept segregated from other wastes in the two waste storage tanks. Primary water is drained directly from the buffer seal surge tank to the waste storage tanks. This water may be put back into the PP system by the primary makeup pump (PD-P2).

The containment vessel is drained by opening the diaphragm valve (PD-21V), which is operated from the console. A containment vessel liquid level alarm (PD-13) is located at the main control console. The containment drain tank (PD-T4) high level is indicated and alarmed in the control room. This tank is drained by the waste transfer pump (PD-P1) to an inner bottom tank.

The contents of the lab waste tank, the makeup tanks, and the inner bottom tanks can be sampled. To obtain representative samples of the lab waste tank and inner bottom tanks, the contents are circulated through the tanks while a sample is being taken. A motor-driven agitator mixes the contents of the waste tank. After the contents of a tank are mixed, the waste transfer pump provides circulation through the sampling bombs. An additional connection to the lab waste tank for obtaining a sample is located inside the secondary shield. To obtain a representative sample of the makeup tanks, the primary makeup pump is used to recirculate the tank contents and to provide circulation to the sampling sink and return lines.

A priming system is provided to prime the waste transfer pump when taking suction from one of the inner bottom tanks. Lines to overboard discharge and dockside are provided from the discharge of the waste transfer pump.

A makeup line is provided from the primary makeup pump discharge to the PP system. Expansion drainage from plant heatup is stored in the waste storage tanks. During a subsequent plant cooldown, this stored expansion drainage is pumped back into the system as makeup.

All of the tanks in the drain system are vented to the WL system. Vacuum breakers, which admit air into the tanks, enable purging of the tank gas voids by the WL system.

Located inside the secondary shield area there are two drain wells which would receive drainage from the tank top should there be any. A sump pump controlled by a float is located in each drain well.

Two valved leakoff lines from the reactor are used to check the effectiveness of the reactor head closure gaskets.

The piping arrangement permits transfer of the contents of one tank to another tank.

The waste dilution and disposal system (WD system) is connected to the PD system at two points:

1. The overboard discharge line.
2. The outlet header for the port and starboard charge pump leakoff tanks.

The waste dilution pump is a diaphragm reciprocating pump with a variable flow of approximately 0 to 33 gph.

The buffer seal charge pump leakoff tanks, which are closely associated with this system, are arranged so that the pump leakage may be transferred to the inner bottom tanks with the waste transfer pump.

Overboard discharge of waste is kept within the limits prescribed by the Technical Specifications. Dilution to acceptable levels may be accomplished by mixing high-activity waste with the condenser salt water flow by injection into the condenser inlet.

9.3.2. Gaseous Waste Collection and Disposal System

9.3.2.1. Function

The function of the gaseous waste collection and disposal system (WL system), shown in Drawing WL 39-J-395, is to provide for venting of components and equipment in the reactor systems with a minimum of shipboard area contamination.

9.3.2.2. Description

The vent facilities are divided into two sections:

1. The section which vents equipment in the containment vessel.
2. The section which vents equipment in the secondary shield.

Potentially radioactive gases from equipment inside the containment are collected in two vent headers and piped to the containment drain tank (PD-T4). The containment drain tank is in turn vented to a manifold (WL-F6) located inside the secondary shield. The vent line to the gas manifold contains two diaphragm-operated valves (WL-20V and WL-110V), which automatically close in the event of high containment vessel pressure.

The following equipment located inside the containment vessel is vented to the containment drain tank:

1. Pressurizer.
2. Primary pumps.
3. Steam generators (primary side).
4. Effluent condensing tank.
5. Secondary side of the purification letdown coolers.
6. Reactor head.
7. Containment drain tank.

The remote-operated vent (WL-1V) for the pressurizer has been provided to avoid radioactive gas accumulation in the pressurizer. This vent operates as a pressurizer bleed and is piped to the PP system so that radioactive and noncondensible gases will be transferred to the buffer seal surge tank.

The equipment inside the secondary shield vents to manifold WL-F6. From the manifold, the gases flow through a line to the inlet duct of the ventilation filters.

Potentially radioactive gas sources outside the containment vessel consist of:

1. The PP system demineralizers.
2. The PP system effluent filters.
3. The buffer seal surge tank.
4. The liquid waste storage tank.

The vent lines for the buffer seal surge tank and the waste storage tank contain flame arrestors to minimize the possibility of hydrogen explosions.

The radiation monitoring system monitors the radioactivity level of the containment air, the secondary shield area air, the vent gas manifold discharge, and the stack discharge on both sides of the filters. This monitoring determines the activity released to the environment.