9.0 AUXILIARY SYSTEMS

A legend for the figures in Chapter 9 is located on Figure 9-1.

9.1 CHEMICAL AND VOLUME CONTROL SYSTEM

9.1.1 DESIGN BASIS

The Chemical and Volume Control System (CVCS) is designed to perform the following functions:

a. Maintain reactor coolant activity at the desired level by removing corrosion and fission products;

b. Inject chemicals into the Reactor Coolant System (RCS) to control coolant chemistry and minimize corrosion;

c. Control the reactor coolant volume by compensating for coolant contraction or expansion resulting from changes in reactor coolant temperature and other coolant losses or additions;

d. Provide means for transferring fluids to the radioactive Waste Processing System (WPS);

e. Inject concentrated boric acid into the RCS upon a safety injection actuation signal (SIAS);

f. Control the reactor coolant boric acid concentration;

g. Provide auxiliary pressurizer spray for operator control of RCS pressure during shutdown;

h. Provide a means for functionally testing the check valves which isolate the Safety Injection (SI) System from the RCS (Although this is a design function of the CVCS, these check valves are functionally tested in accordance with the Inservice Test Program.), and for hydrostatic and leak testing of the RCS;

i. Provide continuous on-line measurement of reactor coolant fission product activity.

Portions of the letdown system are American Society of Mechanical Engineers (ASME) Class 1, and thus require a fatigue analysis of the applicable thermal shock transients, and other operational cycles. In addition to design cyclic transients a, d, and e of Section 4.1.1, the letdown system fatigue analysis considers 200 events where letdown flow is lost for an extended period of time. After the letdown piping has cooled to ambient temperature, a restart of letdown flow results in a rapid increase to RCS temperature. See Reference 1 for further details.

Portions of the charging system are ASME Class 1, and thus require a fatigue analysis of the applicable thermal shock transients, and other operational cycles. In addition to design cyclic transients a, b, c, d, e, and g of Section 4.1.1, the charging system fatigue analysis considers 200 loss of letdown events and 200 loss of charging events. Also, certain auxiliary spray transients must be considered for portions of the charging system. See Reference 2 for details on the assumed temperatures and sequence of events of these transients.

Gas accumulation in this water system can result in water hammer, pump cavitation and pumping of non-condensable gas into the reactor vessel. These effects may result in the system being unable to perform its specified safety function. The NRC issued Generic Letter 2008-01, Managing Gas Accumulation, to address the issue of gas accumulation in this system. See UFSAR Section 1.8.5 for further information.

9.1.2 SYSTEM DESCRIPTION

9.1.2.1 General

The CVCS is shown in Figures 9-3 (Unit 1) and 9-24 (Unit 2). Coolant normally flows through the CVCS, as shown in Figures 9-3 and 9-24. Coolant letdown from one reactor coolant loop cold leg first passes through the tube side of a regenerative heat exchanger where the temperature is reduced to approximately 232°F and then through the letdown control valves. The letdown control valves, which are modulated by the pressurizer level control system, control the letdown flow to maintain proper pressurizer level. The letdown coolant temperature is reduced to 120°F at the letdown heat exchanger downstream of the letdown control valves. This temperature is selected to prevent deterioration of the ion exchange resins downstream. Flashing of the hot liquid between the letdown control valves and the letdown heat exchanger is prevented by controlling back pressure with a pressure control valve downstream of the letdown heat exchanger.

The cooled letdown next passes through one of two purification filters which remove suspended solids from the letdown before it enters an ion exchanger. The purified flow from the ion exchanger is sprayed into the Volume Control Tank (VCT) after passing through a strainer.

Charging pumps take suction from the VCT to add makeup coolant to the RCS via the shell side of the regenerative heat exchanger.

A small bypass flow around the purification filters passes through a process radiation monitor (to measure coolant activity). The proper flow rate is obtained by throttling the process radiation monitor outlet valve. There is also an indicating alarm on the discharge to monitor flow and alarm on a low flow condition.

If the level in the VCT reaches the high level setpoint, the letdown flow is automatically diverted to the liquid WPS. If the level in the VCT reaches the low-level setpoint, makeup water, borated to the existing concentration of the RCS, can be automatically supplied to the VCT. During normal operation when the level in the VCT reaches the low-low level setpoint, the tank discharge valve shuts and the suction of the charging pump is automatically aligned to the Refueling Water Tank (RWT).

With the level in the normal control band, the VCT has sufficient capacity to accommodate the variation in water inventory of the RCS due to power level changes in excess of that accommodated by the pressurizer.

Boric acid required for makeup can be supplied from either boric acid batching or from the boron recovery system. The boron recovery system is described in Section 11.1.2. The concentrated boric acid is stored in two heated storage tanks. Two pumps are provided to transfer concentrated boric acid. The piping is arranged such that the boric acid may be mixed with demineralized water in a predetermined ratio prior to being introduced to the VCT.

Chemicals are introduced to the RCS directly from a chemical addition tank or via a chemical addition metering pump, both of which are connected to the charging pump suction header.

The RCS may be tested for leaks when the plant is shut down using a charging pump for pressurization. The system is also provided with connections for installing a hydrostatic test pump.

9.1.2.2 Volume Control

The CVCS automatically adjusts the volume of water in the RCS using a signal from level instrumentation located on the pressurizer. The system reduces the amount of fluid that must be transferred between the coolant system and the CVCS during power changes by employing a programmed pressurizer level setpoint which varies with reactor power level. The setpoint varies linearly with the average reactor coolant temperature. This linear relationship is shown in Figure 4-10 (Section 4.3). The control system compares the programmed level setpoint with the measured pressurizer water level. The resulting error signal is used to control the operation of the charging pumps and the letdown valves, as described below. The pressurizer level control program is shown in Figure 4-11.

The pressurizer level control program regulates the letdown flow by adjusting the letdown control valve, so that the RCP controlled bleed-off plus the letdown flow matches the input from the operating charging pump. When the equilibrium is disturbed by a power change or for any other reason, a decrease in level will start one or both standby charging pumps to restore level, and an increase in level will increase the letdown flow rate and initiate a backup signal to stop the two standby charging pumps.

The VCT coolant level can be automatically controlled. When the level in the tank reaches the high-level setpoint, the letdown flow is automatically diverted to the liquid waste processing system. If the makeup mode selector switch is in auto when the level in the tank reaches the low-level setpoint, makeup water is automatically supplied.

When the Control Room handswitches for the VCT outlet valve and RWT charging pump suction valve are in AUTO, and the level in the VCT reaches the low-low-level setpoint, the VCT outlet valve automatically closes and the RWT charging pump suction valve automatically opens, realigning the suction of the charging pumps to the RWT. On a loss of power to the level transmitter controlling this automatic action, the handswitch for the VCT outlet valve is placed in OPEN and the handswitch for the RWT charging pump suction valve is placed in CLOSE to reverse the automatic realignment that occurs. In this condition, VCT level can still be monitored in the Control Room from an indicator that is supplied from an independent power source.

The VCT can be vented to the WPS. The tank is normally operated with sufficient hydrogen partial pressure such that the RCS hydrogen concentration is consistent with plant chemistry requirements as discussed in Sections 4.1.4.2.3 and 9.1.2.3. However, other gases dissolved in the reactor coolant can leave solution when the letdown flow is sprayed into the VCT.

9.1.2.3 Chemical and Reactivity Control

The CVCS purifies and conditions the coolant by means of ion exchangers, filters, degasification and chemical additives. The purification ion exchangers contain a mixed resin bed which removes soluble impurities by ion exchange and suspended impurities by impaction of the particles on the surface of the resin beds.

Cartridge-type filters located upstream of the ion exchangers remove most of the suspended impurities to prevent clogging of the resin beds.

Dissolved gases may be removed from the coolant by venting the VCT and purging with nitrogen as required.

The reactor coolant is chemically conditioned to the typical conditions recommended in the EPRI PWR Primary Water Chemistry Guidelines:

a. Hydrazine scavenging to remove oxygen prior to exceeding 250°F;
b. Maintaining excess hydrogen concentration to control oxygen concentration and suppress radiolysis when the reactor is critical;
c. Chemical additives to control pH when the reactor is critical. As an exception to the Electric Power Research Institute Guidelines, the RCS lithium concentration may be as high as 5.33 ppm for approximately the first 4 effective full power days and 5.30 ppm for the remainder of the fuel cycle to optimize RCS pH.
d. Low levels of zinc acetate may be added to Units 1 and 2 for purposes of reducing dose and mitigating primary water stress corrosion cracking.
e. Hydrogen peroxide may be added at shutdown to promote dissolution of radiocobalt and scavenge hydrogen.

The chemical addition tank or chemical addition metering pump is used to feed chemicals to the charging pumps which inject the additives into the RCS. The reactor coolant makeup pumps can inject hydrazine into the makeup train to scavenge dissolved oxygen.

The CVCS is designed to prevent fission and corrosion product activities from exceeding the values given in Chapter 11 when operating with 1% failed fuel.

Reactivity Control

The boron concentration of the reactor coolant is controlled by the CVCS to:

1. Optimize the position of the control rods;
2. Compensate for reactivity changes caused by variations in the temperature of the coolant, and by burnup of the core;
3. Provide a margin of shutdown for maintenance, refueling or emergencies.

The system includes a batching tank for preparing boric acid solution, two tanks for storing the solution, and two pumps for supplying boric acid solution to the makeup system. Boric acid from the waste processing system is pumped to either the boric acid storage or batching tanks.

Normally, the CVCS adjusts the boric acid concentration of the coolant by feed and bleed. To change concentration, the makeup (feed) system supplies either demineralized water or concentrated boric acid to the VCT or directly to the charging pump suction header, and the letdown (bleed) stream is diverted to the WPS. Toward the end of a core cycle, an ion exchanger is used to deborate. This avoids the excessive quantity of waste produced due to the feed and bleed operations.

The system can add boric acid to the reactor coolant at a sufficient rate to override the maximum increase in reactivity due to cooldown and the decay of xenon in the reactor. The control element assemblies (CEAs) can decrease reactivity far more rapidly than the boron removal system can increase reactivity.

The charging pumps may be used to leak test the RCS at normal operating pressure when the plant is shut down. Leaks in the RCS may be detected while the plant is at power by monitoring pressurizer level, VCT level, letdown flow, reactor coolant drain tank level, coolant temperature, and charging flow rate.

9.1.3 SYSTEM COMPONENTS

The major components of the CVCS and their functions are described in this section.

9.1.3.1 Description

Regenerative Heat Exchanger

The regenerative heat exchanger (Table 9-3) transfers heat from the letdown stream to the charging stream. Materials of construction are primarily austenitic stainless steel.

Letdown Control Valves

The letdown control valves (Table 9-4) regulate the reactor coolant flow from the regenerative heat exchanger as required by the pressurizer level regulating system. The valves reduce the pressure of the letdown fluid to about 460 psig. This value prevents flashing with about a 30 psi margin, even with minimum makeup flow (44 gpm charging) and maximum letdown flow (128 gpm) [Table 9-1, note (a)]. The letdown flow is nominally 38 gpm, for coolant purification, but will vary as the pressurizer water level changes. The valves are pneumatically-operated and fail closed. All parts in contact with reactor coolant are of austenitic stainless steel.

Letdown Heat Exchanger

The letdown heat exchanger (Table 9-5) cools the letdown stream in the tube side of the regenerative heat exchanger to a temperature suitable for entry into a purification ion exchanger. Component cooling system fluid is the cooling medium on the shell side of the letdown heat exchanger. Tube side materials of construction are primarily austenitic stainless steel; shell side materials of construction are primarily carbon steel [Table 9-1, note (a)].

Ion Exchangers

Three purification ion exchangers (Table 9-6) are available to purify and remove boron from the reactor coolant. These ion exchangers are identical in design and may be interchanged during operation. Each unit is designed to handle the maximum letdown flow of 128 gpm [Table 9-1, note (a)]. The vessels and resin retention element are of austenitic stainless steel construction.

Mixed bed resin is loaded into an Ion Exchanger to purify the reactor coolant by removing corrosion and fission products. Toward the end of core life, resin is loaded into one or more ion exchangers to reduce boron concentration in the reactor coolant. This method is preferable to using feed and bleed since it minimizes the volume of radioactive waste water produced.

Purification Filters

The purification filters (Table 9-7) remove suspended impurities from the reactor coolant. Each filter will accommodate maximum letdown flow of 128 gpm. The filter housings are austenitic stainless steel.

Volume Control Tank (VCT)

The VCT (Table 9-8) accumulates water from the RCS. The tank has sufficient capacity to accommodate the variation in water inventory of the RCS due to power level changes in excess of that accommodated by the pressurizer. The tank provides a gas space where a partial pressure of hydrogen and nitrogen is maintained to control the hydrogen and nitrogen concentration in the reactor coolant. A vent to the WPS permits removal of hydrogen, nitrogen and gaseous fission products released from solution in the VCT. The tank is of austenitic stainless steel construction and provided with overpressure protection. Level controls divert coolant to the WPS on high level or operate coolant makeup valves on low level.

With respect to quality control (QC) the CVCS volume control tanks, purchased using Combustion Engineering, Inc. (CEs) generic specification WQC-11.1, Level II, required the following:

a. The manufacturer was required to maintain a quality assurance system acceptable to CE. This system included inspection and testing procedures, a manufacturing and QC plant, control of procedure revisions and control and submittal of documents and records.
b. The manufacturer was required to have written procedures which ensured the latest applicable drawings, specifications and instructions were used for fabrication, inspections and tests and ensured control over all measuring and testing equipment.
c. The manufacturer was responsible for assuring that all supplies and services procured from his suppliers (sub-contractors and vendors) conformed to the contract requirements.
d. The QC program of the manufacturer was required to ensure that raw material to be used in fabrication or processing products conformed to the applicable physical, chemical and all other technical requirements. The identification of all material was maintained throughout all operations by job number, lot number, heat number or any other suitable identification means and recorded on proper inspection records for each component.
e. The manufacturer was informed that all processing, testing and insertion operations taking place in the supplier's or subcontractor's facilities were subject to CE/Baltimore Gas and Electric Company (BGE) quality surveillance and verification.

Charging Pumps

Three positive displacement charging pumps (Table 9-9) supply makeup water to the RCS. The pumps return coolant to the RCS. On a SIAS, all three pumps are started and discharge concentrated boric acid into the RCS. All wetted parts, except seals, are of stainless steel and titanium. The charging pumps have a design flow of 44 gpm each.

Concentrated Boric Acid Tanks

Each of the two concentrated boric acid tanks (Table 9-10) stores enough concentrated boric acid solution to bring the reactor to a cold shutdown condition at any time during the core lifetime. The solution is either prepared in the boric acid batching tank and flows through the boric acid batching strainer before entering the storage tanks or is obtained from the boron recovery system. The combined capacity of the tanks will also be sufficient to bring the coolant to refueling concentration. The tanks have duplicate electric heaters to maintain a temperature above the saturation temperature of the concentrated solution, and sampling connections are used to verify that proper concentration is maintained. The tanks are constructed of stainless steel.

Boric Acid Pumps

The two boric acid pumps (Table 9-11) supply concentrated boric acid solution through the boric acid strainer (Table 9-11) to the makeup system where the boric acid may be diluted with demineralized water. On receipt of SIAS, these pumps line up with the charging pumps to permit direct introduction of concentrated boric acid into the RCS. Each is capable of supplying boric acid at the maximum demand conditions. Wetted parts of the pumps are stainless steel.

Process Radiation Monitor

The process radiation monitor (Table 9-13) continuously measures the activity of the reactor coolant and actuates an alarm in the Control Room if a predetermined activity level is reached. The sensor is a gross-gamma plus specific isotope (I-135) monitor; the system is designed to detect activity release from the fuel to the reactor coolant within five minutes of the event.

9.1.3.2 Codes and Standards

All components are designed, manufactured, tested and inspected according to applicable codes. The following code classifications apply to the CVCS components:

Regenerative Heat Exchanger	ASME III Class C[(a)]
Letdown Heat Exchanger	ASME III Class C
Deborating Purification Demineralizers	ASME III Class C
Purification Filters	ASME III Class C
Volume Control Tank	ASME III Class C
Boric Acid Storage Tanks	ASME III Class C

[(a)] The regenerative heat exchanger is built as a Class A vessel, but is stamped Class C.

9.1.3.3 Testing and Inspection

Each component is inspected and cleaned prior to installation into the system. Demineralized water will be used to flush each system.

Instruments will be calibrated during testing. Automatic controls will be tested for actuation at the proper setpoints. Alarm functions will be checked for operability and limits during preoperational testing. The relief valve setpoints will be checked.

The system will be operated and tested initially with regard to flow paths, flow capacity and mechanical operability. At least one pump of each type will be tested to demonstrate head and capacity.

Data will be taken periodically during normal plant operation to confirm heat transfer capabilities and purification efficiency.

9.1.4 SYSTEM OPERATION

9.1.4.1 Startup

During startup, the plant is brought from cold shutdown to hot standby at normal operating pressure and zero power temperature, before the reactor is brought critical. While the coolant is being heated, and until the pressurizer steam bubble is established, the charging pumps and letdown backpressure valve are used to maintain pressure in the RCS. After a steam bubble is established in the pressurizer, the operator adjusts the pressurizer water level manually with the letdown backpressure and letdown control valves. The level controls of the VCT automatically divert the letdown flow to the WPS.

While the reactor is shut down, the VCT can be vented to the WPS. Prior to startup, the tank is purged with nitrogen to remove air. After purging is completed, the vent is secured and a nitrogen-hydrogen blanket is established in the tank. Any oxygen in the reactor coolant is normally removed by radiolytic recombination with excess hydrogen in the coolant. However, should the residual radiation from the core be insufficient to reduce the oxygen level, hydrazine can be added to scavenge the oxygen if the temperature is below 250°F.

Throughout startup, one purification filter is in service to reduce the activity of wastes entering the WPS. When the letdown temperature is stabilized at the desired RCS hot standby temperature, one or more purification ion exchangers are put into service as required.

Within limitations placed on the shutdown margin, the boric acid concentration may be reduced during heatup. The operator may inject a predetermined amount of demineralized makeup water by operating the system in the makeup controller "Dilute" mode. The concentration of boric acid in the reactor coolant is determined by chemical analysis.

For the initial reactor startup following refueling, the RCS soluble boron concentration shall remain at or above refueling boron concentration until all four RCPs are running with RCS $T_{avg} \geq 515°F$ in Mode 3. After meeting those conditions, the RCS boron concentration may be reduced to that required to satisfy Mode 3 Shutdown Margin with no credit taken for the highest CEA bank worth. After successfully completing CEA rod drop time testing and with all shutdown CEA banks in the fully-withdrawn position, then additional RCS dilution may proceed.

9.1.4.2 Normal Operation

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

During normal operation:

a. Level instrumentation on the pressurizer automatically controls the volume of water in the reactor system by adjusting the letdown flow.

b. The VCT level is increased manually by the operator using makeup and automatically decreased by diversion to the WPS. Level can also be controlled by automatic makeup.

c. The hydrogen concentration and pH of the coolant are adjusted.

d. Changes in reactivity may be compensated for by adjusting the concentration of boric acid in the reactor coolant. Throughout most of the cycle, changes in boron concentration are effected by feed-and-bleed, discharging the excess coolant to the WPS. Late in cycle life, the dissolved boron in the reactor coolant is maintained at a very low concentration; at this time, feed-and-bleed generates excessive radioactive wastes; further reduction is accomplished by use of a purification ion exchanger with deborating resin. The makeup system may be operated in four modes:

    1. In the "Dilute" mode, a quantity of demineralized makeup water is selected and introduced into the VCT or directly to the charging pump

suction header at a preset rate. When the integrating flowmeter indicates that the selected quantity of makeup water has been added, the flow is automatically terminated.

2. In the "Borate" mode, a quantity of concentrated boric acid is selected and introduced at a preset rate as described above.
3. In the "Manual" mode, the flows of the demineralized water and concentrated boric acid are set for any blend concentration between demineralized makeup water and concentrated boric acid. This mode is primarily used to supply the VCT. It is also used for positive reactivity control during power operation.
4. In the "Automatic" mode, the flow rates of the demineralized water and concentrated boric acid are set to achieve the concentration present in the reactor coolant. The solution is automatically blended and introduced into the VCT according to signals received from the VCT level program.

e. The letdown flow is routed through one of the purification ion exchangers to reduce coolant activity resulting from soluble and insoluble corrosion and fission products.

9.1.4.3 Cooldown

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

Before the plant is cooled down, the VCT is vented to the WPS to reduce the activity and the hydrogen concentration in the reactor coolant. The operator may also increase the letdown flow rate to accelerate degasification, ion exchange and filtration of the reactor coolant. The operator increases the concentration of boric acid in the reactor coolant to ensure that the reactor has an adequate shutdown margin throughout its period of cooldown.

During cooldown, makeup water is introduced at the shutdown boric acid concentration. When the CVCS makeup system is in the automatic mode, a preset boric acid solution is automatically blended and introduced into the VCT upon demand from the VCT level program. The preset solution concentration corresponding to the desired shutdown concentration will have been previously determined and selected on the blender switch by the operator. During the cooldown, the charging pumps and letdown control valves are used to adjust and maintain the pressurizer water level. High charging flow results in a low level in the VCT which sounds an alarm. The operator then manually makes up fluid volume at the preselected shutdown boric acid concentration.

The estimated dissolved boron in the reactor coolant required to maintain cold shutdown conditions is shown in curves found in the Nuclear Engineering Operating Procedure (NEOP).

The total volume of both concentrated boric acid storage tanks is also sufficient to bring the RCS to refueling concentration.

A portion of the charging flow is used as an auxiliary spray to cool the pressurizer when the pressure of the RCS is below that required to operate the RCPs.

9.1.4.4 Safety Injection

Under event conditions, the charging pumps are used to inject concentrated boric acid into the RCS. Either the pressurizer level control system or SIAS will automatically start all charging pumps. The SIAS will also function to transfer the charging pump suction from the VCT to the discharge of the boric acid pump. If the boric acid pumps are not operable, boric acid flows by gravity from the concentrated boric acid tanks to the charging pump suction header. If the charging line inside the reactor containment building is inoperative, the line may be isolated outside the reactor containment, and the concentrated boric acid solution may be injected by the charging pumps through the high-pressure safety injection (HPSI) piping.

9.1.5 DESIGN EVALUATION

To assure reliability, the design of the CVCS incorporates redundant critical components to reduce dependence upon any single critical component. Redundancy is provided as follows:

Component	Redundancy
Purification Demineralizer	Parallel Standby Unit
Purification Filters	Parallel Standby Unit
Charging Pump	Two Parallel Standby Units
Letdown Flow Control	Parallel Standby Valve
Letdown Backpressure Regulator	Parallel Standby Valve
Boric Acid Pump and Tank	Parallel Standby Unit

The charging and boric acid pumps are powered by the diesel generators if normal power sources are lost. One charging pump and one boric acid pump are supplied from each emergency bus. The third charging pump may be supplied from either emergency bus. Physical separation and barriers are provided between the power and control circuits for the redundant pumps.

Standby features are provided so that at least one charging pump is running after SIAS. If two diesel generators are available, both boric acid pumps will be running. The charging pumps and boric acid pumps may be controlled locally at their switchgear. Separate power supplies for pump power and separate control circuits assure that this system satisfies the single failure criterion.

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

9.1.6 REFERENCES

1. Bechtel Specification 6750-M-0310C, "Design Specification for Piping, Valves, and Associated Equipment of the Letdown System"
2. Bechtel Specification 6750-M-0310D, "Design Specification for Piping, Valves, and Associated Equipment of the Charging System and Auxiliary Spray System"

TABLE 9-1

CHEMICAL AND VOLUME CONTROL SYSTEM PARAMETERS

Normal Letdown and Purification Flow, gpm[a]	38
Normal Charging Flow, gpm	44
Reactor Coolant Pump Controlled Bleedoff (4 pumps), gpm[a]	6
Normal Letdown Temperature at Loop °F	548
Ion Exchanger Operating Temperature, °F	120

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[a] The original design for normal letdown and purification flow rate was 40 gpm with 4 gpm of reactor coolant pump controlled bleedoff. (The maximum letdown and purification flow rate was 128 gpm with 4 gpm controlled bleedoff.) These flows combined to equal the normal charging flow rate of 44 gpm (maximum charging flow rate of 132 gpm). Facility Change Request (FCR) 87-0074 replaced the reactor coolant pump seal with a state-of-the-art design that requires 1.5 gpm (nominal) controlled bleedoff per pump for stable operation. The net effect of this FCR was to reduce the normal letdown and purification flow rate to 38 gpm (the maximum letdown and purification flow rate was reduced to 126 gpm) and increase the reactor coolant pump controlled bleedoff rate to 6 gpm (total for all four pumps).

TABLE 9-3

REGENERATIVE HEAT EXCHANGER

DESIGN PARAMETERS

Quantity	1
Type	Shell and Tube, Vertical
Code	ASME III, Class C[(a)]
Tube Side (Letdown) Fluid	Reactor Coolant, 1.5 wt% Boric Acid, Maximum
Design Pressure, psig	2485
Design Temperature, °F	650
Materials	Stainless Steel, Type 304
Pressure Loss at 63,500 lb/hr	99
Shell Side (Charging) Fluid	Reactor Coolant, 6.25 wt% Boric Acid, Maximum
Design Pressure, psia	3025
Design Temperature, °F	650
Materials	Stainless Steel, Type 304
Pressure Loss at 132 gpm, psi	70

(a) The regenerative heat exchanger is built as a Class A vessel, but is stamped Class C.

DESIGN OPERATING PARAMETERS - REGENERATIVE HEAT EXCHANGER

TUBE SIDE (LETDOWN)	NORMAL	MAXIMUM UNBALANCED CHARGING WITH HEAT TRANSFER	MAXIMUM PURIFICATION	MAXIMUM UNBALANCED LETDOWN
Flow – gpm [Table 9-1 note (a)]	38	30	126	126
Inlet Temp. - °F	548	548	548	548
Outlet Temp. - °F	232	143	350	433
Shell Side (Charging)				
Flow – gpm	44	132	132	44
Inlet Temp. - °F	120	120	120	120
Outlet Temp. - °F	415	220	324	475

TABLE 9-4

LETDOWN CONTROL VALVES

Quantity	2
Design Pressure, psia	2500
Design Temperature, °F	650
Flow, each	
Maximum, gpm	128
Minimum, gpm	29

TABLE 9-5

LETDOWN HEAT EXCHANGER

DESIGN PARAMETER

Quantity	1
Type	Shell and Tube, Horizontal
Code	ASME III, Class C
Tube Side (Letdown) Fluid	Reactor Coolant, 1.5 wt% Boric Acid, Maximum
Design Pressure, psig	650
Design Temperature, °F	550
Pressure Loss at 63,500 lb/hr, psi	52
Materials	Stainless Steel, Type 304
Shell Side (Cooling Water)	
Fluid	Component Cooling Water
Design Pressure, psig	150
Design Temperature, °F	250
Materials	Carbon Steel
Design Flow, lb/hr	594,390

DESIGN OPERATING PARAMETERS

TUBE SIDE (LETDOWN)	NORMAL	MAXIMUM UNBALANCED CHARGING WITH LETDOWN	MAXIMUM PURIFICATION	MAXIMUM UNBALANCED LETDOWN
Flow - gpm [Table 9-1 note (a)]	38	30	126	126
Inlet Temp. - °F	232	143	350	433
Outlet Temp. - °F	120	120	125	135
Shell Side (Cooling Water)				
Flow - gpm	157	21	1200[a]	1200[a]
Inlet Temp. - °F	95	65	95	95
Outlet Temp. - °F	122	128	118	127

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[a] This flowrate represents design points selected during the design of the system and components. It does not indicate the normal operating point or minimum or maximum limitation of the system or components.

TABLE 9-6
ION EXCHANGERS

Quantity	3
Type	Flushable
Design Pressure, psig	200
Design Temperature, °F	250
Normal Operating Pressure, psig	60
Normal Operating Temperature, °F	120
Resin Volume, ft^3, each	36
Normal Flow, gpm	38
Maximum Flow, gpm	128 [Table 9-1, note (a)]
Code for Vessel	ASME III, Class C
Material	ASME SA 240, Type 304
Fluid, wt% Boric Acid, Maximum	1.5

TABLE 9-7

PURIFICATION FILTERS

Quantity	2
Type of Elements	Single Element Disposable Cartridge
Filter Rating, microns (absolute)	0.1 to 6.0, various, depending on plant conditions
Vessel Design Pressure, psig	200
Vessel Design Temperature, °F	250
Design Flow, gpm	128 (Table 9-1, note (a)]
Normal Flow, gpm	38
Code for Vessel	ASME III, Class C
Material	Austenitic Stainless Steel
Fluid, wt% Boric Acid, Maximum	1.5

TABLE 9-8

VOLUME CONTROL TANK

Quantity	1
Type	Vertical, Cylindrical
Design Pressure, Internal, psig	75
Design Pressure, External, psig	15
Design Temperature, °F	250
Operating Pressure Range, psig	0 to 65
Normal Operating Pressure, psig	25 to 50
Normal Operating Temperature, °F	120
Normal Spray Flow, gpm	38
Blanket Gas	Hydrogen and/or Nitrogen
Code	ASME III, Class C
Fluid, wt% Boric Acid, Maximum	12
Material	Austenitic Stainless Steel

TABLE 9-9

CHARGING PUMPS

Quantity	3
Type	Positive Displacement
Design Pressure, psig	2735
Design Temperature, °F	250
Capacity, gpm	44
Normal Discharge Pressure, psig	2311
Normal Suction Pressure, psig	50
Normal Temperature of Pumped Fluid, °F	120
Maximum Discharge Pressure (Short Term), psig	3010
Minimum NPSH, psia	9
Driver Rating, hp	100
Materials in Contact with Pumped Fluid	Stainless Steel, Titanium
Fluid, wt% Boric Acid, Maximum	12

TABLE 9-10

CONCENTRATED BORIC ACID PREPARATION AND STORAGE

CONCENTRATED BORIC ACID TANKS

Quantity	2
Internal Volume, ft^3	1270
Design Pressure, psig	15
Design Temperature, °F	200
Normal Operating Temperature, °F	150
Type Heater	Duplicate Electrical, Strap-on heaters
Fluid, wt% Boric Acid, Maximum	12
Material	Stainless Steel
Code	ASME III, Class C

BORIC ACID BATCHING STRAINER

Quantity	1
Type	Basket
Design Pressure, psig	150
Design Temperature, °F	200
Screen Size, US Mesh	80
Design Flow, gpm	50
Materials	Stainless Steel
Fluid, wt% Boric Acid, Maximum	12

BORIC ACID BATCHING TANK

Quantity	1
Useful Volume, ft^3	67
Design Pressure	Atmospheric
Design Temperature, °F	200
Normal Operating Temperature, °F	150
Type Heater	Electrical Immersion
Heater Capacity, min, kW	45
Fluid, wt% Boric Acid, Maximum	12
Material	Austenitic Stainless Steel

TABLE 9-11

BORIC ACID PUMPS AND STRAINER

PUMPS

Quantity	2
Type	Centrifugal
Design Pressure, psig	150
Design Temperature, °F	250
Design Head, ft	231
Design Flow, gpm	143
Normal Operating Temperature, °F	150
NPSH Required, ft	20
Horsepower	25
Fluid, wt% Boric Acid, Maximum	12
Material in Contact With Liquid	Stainless Steel

STRAINER

Quantity	1
Type	Basket
Screen Size US Mh	80
Design Pressure, psig	150
Design Temperature, °F	200
Design Flow, gpm	140
Materials	Austenitic Stainless Steel
Liquid, wt% Boric Acid, Maximum	12

TABLE 9-13

PROCESS RADIATION MONITOR

Quantity	1
Design Pressure, psig	200
Design Temperature, °F	250
Normal Operating Pressure, psig	80
Normal Operating Temperature, °F	120
Normal Flow Rate, gpm	0.5
Measurement Range, μCi/cc I-135	10^{-4} to 100(a)
Measurement Range, cpm	10 to 10^6

(a) Upper measurement range of 100 μCi/cc is based upon use of a collimator between detector and sample.