TABLE OF CONTENTS

LIST OF FIGURES

5 CHEMICAL AND VOLUME CONTROL SYSTEM

Learning Objectives:

1. List the purposes of the Chemical and Volume Control System (CVCS).
2. List in flow path order and state the purpose of the following major components of the CVCS:
   a. Regenerative heat exchanger
   b. Letdown flow control valves
   c. Letdown heat exchanger
   d. Letdown back pressure regulator
   e. Letdown filter
   f. Ion exchangers
   g. Volume Control Tank (VCT)
   h. Charging pump
3. Identify the components in the CVCS that are used to purify the reactor coolant and the types of contaminants each is designed to remove.
4. Describe how the makeup system is used to borate, dilute, and makeup a blended flow of boric acid to the Reactor Coolant System (RCS).
5. Explain why and for what plant conditions the following chemicals are added to the RCS:
   a. Lithium hydroxide
   b. Hydrogen
   c. Hydrazine
6. Describe the emergency boration flowpath, and identify the plant conditions which would require its use.
7. List the plant operations that result in large amounts of in fluent into the boron management system.
8. Identify the changes in the CVCS that occur upon the receipt of an Engineered Safety Features Signal (ESF).
9. Explain how the CVCS is designed to prevent the following:
   a. Flashing and pressure transients in the regenerative and letdown heat exchangers.
   b. High temperature in the letdown ion exchangers
10. List the automatic actions initiated by VCT level instrumentation.

5.1 Introduction

The CVCS performs the following functions:

1. Purification of the RCS,
2. Control of RCS boron concentration,
3. Control of RCS volume (pressurizer level),
4. The addition of corrosion inhibiting chemicals to the RCS,
5. Collection of RCP controlled bleed off,
6. Adds boron to the RCS in the event of an accident,
7. Supplies pressurizer auxiliary spray,
8. Provides continuous on-line measurement of RCS boron concentration and RCS activity and
9. Provides a means of testing the high pressure safety injection (HPSI) check valves.

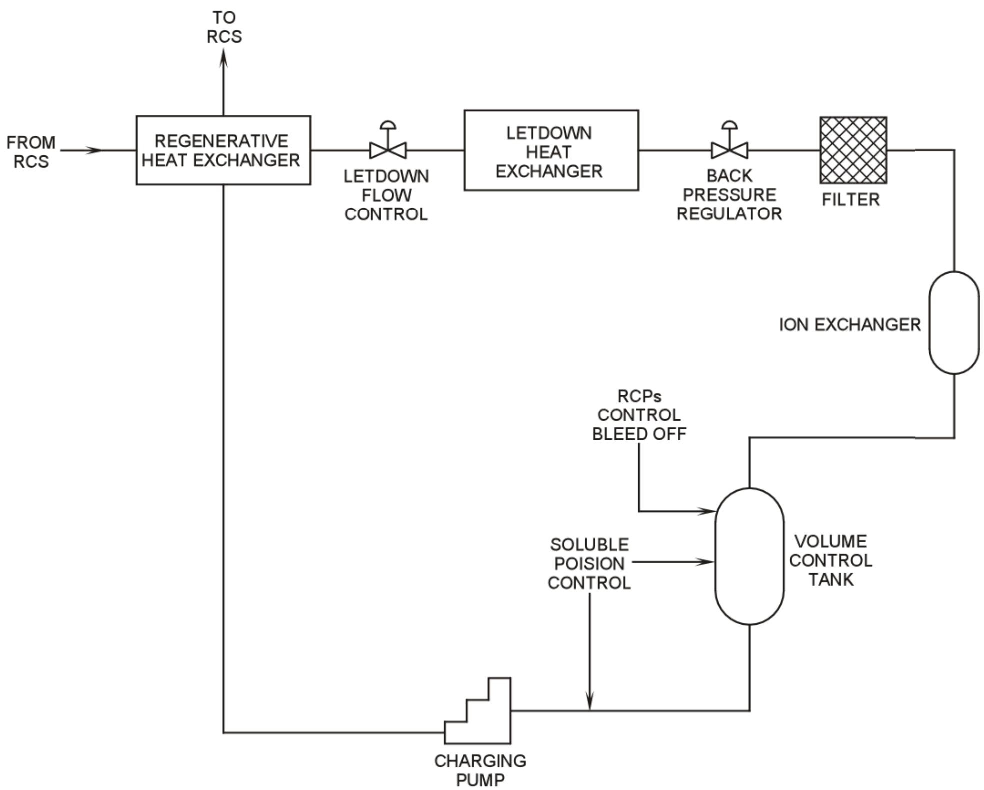

Figure 5-1 Simplified Chemical and Volume Control System

The CVCS is a major system which is in service during most modes of operation. The CVCS (Figure 5-1) starts at the suction of 12A reactor coolant pump (RCP) where coolant is letdown at a flow rate (29 to 128 gpm) dependent upon pressurizer level. The coolant is cooled and depressurized and routed through the purification components. Then the coolant is collected in the VCT. From the VCT, the coolant is pumped back into the RCS by the three 44 gpm capacity charging pumps.

5.2 Letdown

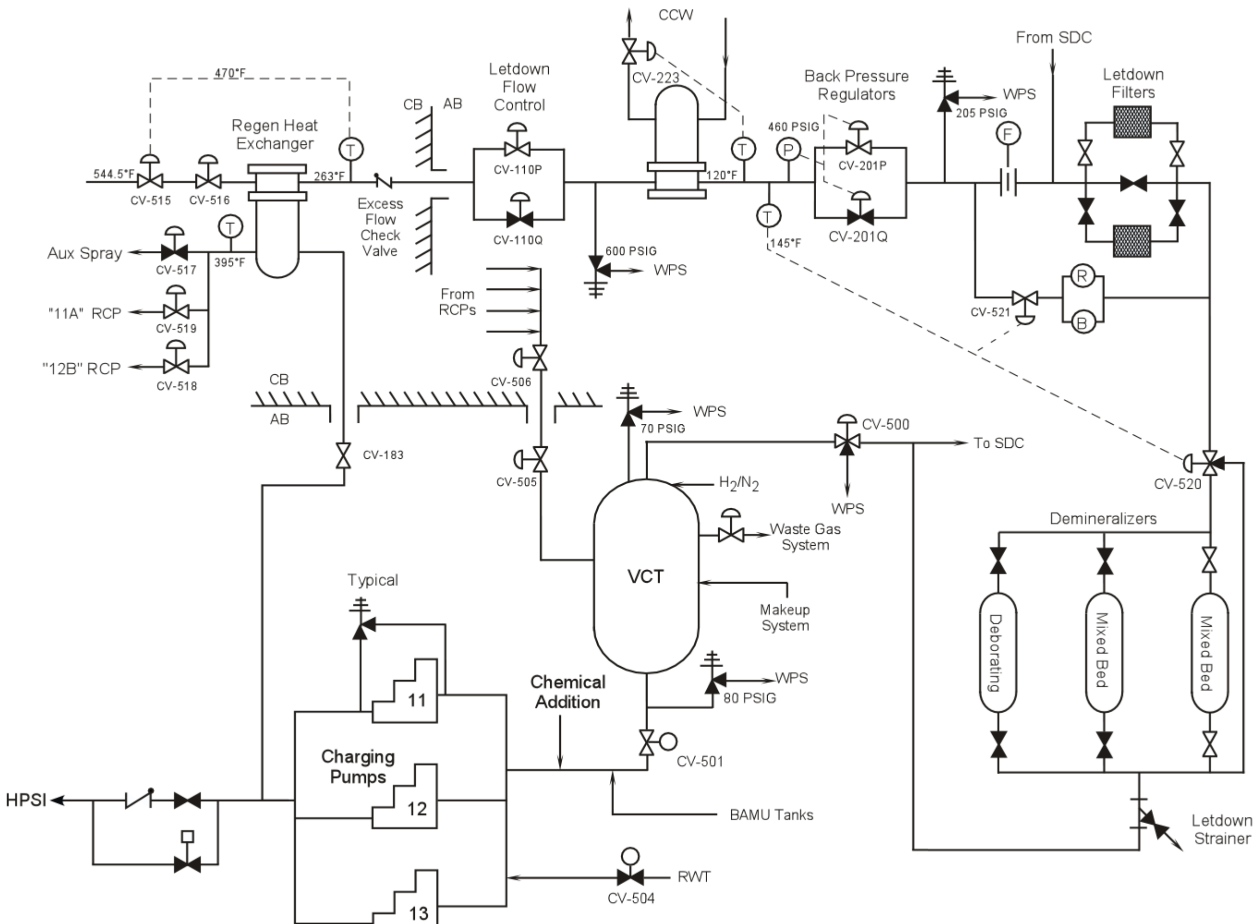

Figure 5-2 CVCS Diagram

In order to accomplish the functions of RCS purification, pressurizer level control, and the control of boron concentration, coolant must be letdown from the RCS. Purification is accomplished by passing the letdown stream through ion exchangers that require low temperature for proper operation; therefore, heat exchangers are installed in the letdown line to reduce the letdown water's temperature. These basic requirements form the design basis for many of the components in the letdown. In the following sections, the letdown subsection will be discussed.

5.2.1 Letdown Isolation Valves

The letdown subsystem starts with a connection located on the suction of a RCP and is routed to the regenerative heat exchanger. Two series air operated valves are installed in this line and provide manual or automatic isolation of the letdown line.

The first of these valves, the letdown stop valve (CV-515), is automatically closed by high regenerative outlet temperature (470°F) or ESF signals. A high regenerative heat exchanger outlet temperature would be caused by a loss of charging flow. Interlocking the letdown isolation valve insures that cooling water is available to the heat exchanger prior to admitting hot letdown. The letdown stop valve is also closed by a safety injection actuation signal (SIAS). The purpose of this interlock is two fold. First, letdown does not perform any safety related functions and all non-safety related penetrations are isolated during accidents. Secondly, isolation of letdown prevents loss of additional inventory during an accident. In addition, a Chemical And Volume Control Isolation Signal (CVCIS) will also close the letdown stop valve. The CVCIS signal functions to isolate the letdown line in the event of a letdown line rupture.

The second series isolation valve (CV-516) is called the letdown containment isolation valve. A SIAS close signal is sent to this valve to provide redundancy in the isolation of letdown. A CVCIS signal also closes the letdown containment isolation valve. Both of the two series valves may be manually operated from the control room. Letdown fluid normally passes through these valves to the regenerative heat exchanger.

5.2.2 Regenerative Heat Exchanger

The regenerative heat exchanger is an inverted U-tube heat exchanger with letdown flowing through the tubes and charging flowing through the shell. By cooling the letdown stream with the returning charging flow, a portion of the temperature loss is regained (the temperature is regenerated).

Cooling letdown provides a part of the temperature reduction that is necessary for proper ion exchange operation, and heating of the charging flow minimizes thermal shock to the RCS and pressurizer penetrations.

Under balanced letdown and charging flows, the letdown enters the heat exchanger at 544.5°F and exits at about 263°F, while charging enters at ~120°F and leaves at 395°F. These temperatures will change as letdown and charging flow rates change. Regenerative heat exchanger outlet temperatures are monitored in the control room.

As previously discussed, regenerative heat exchanger letdown temperature provides an interlock to the letdown stop valve. The letdown outlet of the regenerative heat exchanger travels from the containment building to the auxiliary building.

5.2.3 Excess Flow Check Valve

An excess flow check valve is located downstream of the regenerative heat exchanger and is installed to minimize the consequences of a CVCS letdown line rupture. The valve is a two inch, alloy 316 stainless steel, spring loaded check valve that is designed to operate at 2500 psia and 650°F. The valve will isolate the letdown line if letdown flow exceeds 210 gpm.

After the excess flow check valve, the letdown line passes through the containment penetration. The containment penetration is cooled by a small heat exchanger to prevent the concrete surrounding the penetration from becoming too hot.

The pressures in the piping penetration room and the letdown heat exchanger room are monitored so that if a letdown line rupture occurred in either room, a CVCIS signal would be generated to shut the letdown stop valve and the letdown containment isolation valve. There are two pressure detectors in each room. If any two of the four detectors sense a room pressure of ½ psig, the CVCIS signal will be generated. After passing through the containment letdown isolation valve, letdown travels to the letdown flow control valves.

5.2.4 Letdown Flow Control

The quantity of letdown flow is determined by the position of the letdown flow control valves (CV-110P and CV-110Q) which are modulated by a pressurizer level error. Normally, only one of these valves is in service with the other valve in standby. A selector switch in the control room is used to place either or both valves in service. The selected valve(s) receives the pressurizer level error signal.

During normal operations with a steady pressurizer level, letdown flow is 40 gpm. This 40 gpm combined with a total RCP Controlled Bleed Off (CBO) flow of four gpm matches the 44 gpm capacity of one charging pump. If letdown plus CBO equals charging, pressurizer level should remain constant. However, if pressurizer level starts to drop, then the letdown flow control valve will close to reduce letdown flow. The minimum value of letdown flow is 29 gpm to insure preheating of the charging stream. Conversely, if pressurizer level increases above setpoint, the letdown flow control valve(s) will open to reduce pressurizer level. As the valve opens, letdown flow increases. The maximum value of letdown flow is 128 gpm. This prevents total outflow from the RCS from exceeding the maximum amount of charging. The maximum value of charging, with all three charging pumps running, is 132 gpm. A letdown flow of 128 gpm combined with four gpm RCP CBO equals the charging flow from three pumps.

Both of the letdown flow control valves should never be placed in service when RCS pressure is above 1500 psia because the excessive letdown flow will cause thermal shock to the CVCS.

The pressure drop across the letdown flow control valve is 1630 psi at normal letdown flow. From the letdown flow control valves, flow is directed to the letdown heat exchanger.

The intermediate letdown relief valve is installed in this section of piping to prevent overpressurization of the letdown line and letdown heat exchanger. The valve has a setting of 600 psig (50 psig below piping design pressure) and relieves to the waste processing system.

5.2.5 Letdown Heat Exchanger

The letdown heat exchanger provides the final temperature reduction of the reactor coolant prior to its entry into the ion exchangers. Letdown enters the tubes of this heat exchanger at about 263°F and exits the heat exchanger at about 120°F.

The letdown flow passes through the tube side of the letdown heat exchanger, and component cooling water (CCW) passes through the shell. The shell side of the heat exchanger has baffles installed to direct the flow of CCW in a counter flow direction across the tubes.

Letdown heat exchanger outlet temperature is used to automatically control the flow of CCW. If letdown temperature goes above setpoint, CCW flow is increased by opening the letdown temperature control valve (CV-223) located in the CCW outlet line. Of course, if temperature decreases, CV-223 will close down.

In addition to controlling the CCW flow through the letdown heat exchanger, letdown temperature is used to isolate flow through the boronometer and radiation element, and to bypass flow around the ion exchangers.

5.2.6 Letdown Back pressure Regulators

After letdown temperature has been reduced, its pressure can be reduced. If a pressure reduction was attempted before the water was cooled, then the letdown would flash to steam. In order to prevent flashing, letdown back pressure regulating valves are installed to maintain a pressure of 460 psig on the letdown heat exchanger and upstream piping. 460 psig is greater than the 422 psig saturation pressure that corresponds with a 450°F regenerative heat exchanger outlet temperature. This temperature would be expected if letdown flow was at its maximum value and charging flow was at its minimum.

The back pressure regulating valves (CV-201P and CV-201Q) are automatically modulated by a pressure error signal that is derived by comparing an operator adjusted setpoint (normally 460 psig) and letdown heat exchanger outlet pressure.

During normal operation, only one of the two back pressure regulating valves is in service with the other valve in standby. A selector switch located in the control room is used to place either or both valves in service.

The piping on the downstream side of the pressure regulating valves is protected against over pressure by the low pressure letdown relief. The relief valve is set at 205 psig and relieves to the waste processing system.

An orifice is located in the piping downstream of the back pressure regulating valves and is used as the primary element for control room letdown flow indication.

5.2.7 Boronometer and Radiation Monitor

The boronometer and radiation monitor are installed to provide the operator with indications of RCS boron concentration and activity levels in the reactor coolant.

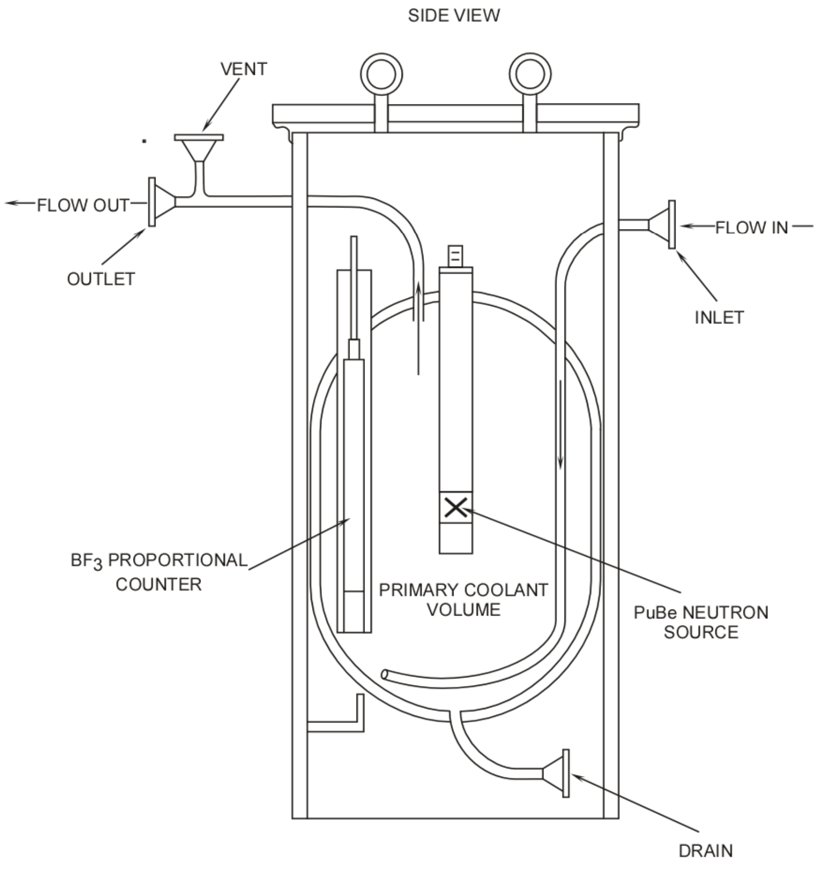

Figure 5-3 Boronometer Assembly

The boronometer (Figure 5-3) consists of a one curie plutonium-beryllium neutron source and four boron triflouride (BF3) detectors. A portion of the letdown flow (~1 gpm) is directed between the neutron source and neutron detectors. Since boron is a neutron absorber, the number of neutrons reaching the detector and the neutron detector's output is inversely proportional to RCS boron concentration.

The boronometer has a range of 0-2050 ppm with an accuracy of ±35 ppm. The accuracy of the boronometer is affected by temperature; therefore, if letdown temperature increases to 145°F, the boronometer is automatically isolated by closing boronometer-radiation monitor isolation valve (CV-521).

A radiation monitor parallels the boronometer. The monitor is designed to monitor gross activity and iodine (I-135) activity. Trends in the values of these two activities aid the operator in determining the cause of RCS activity changes. As an example, if a crud burst occurred, gross activity would increase significantly as compared with changes in I-135 levels. However, if a fuel failure occurs, I-135 activity will increase above its previous steady state values.

The radiation detector is a sodium iodide scintillation detector that supplies a local preamplifier. The output of the preamplifier supplies a linear circuit that supplies the indication of I-135 activity and to a logarithmic circuit that supplies gross activity indication.

The sample flow through the boronometer and radiation monitor rejoins the letdown stream downstream the letdown filters.

5.2.8 Letdown Filters

The letdown filters are installed to provide mechanical purification of the RCS. The filters are of the wound cartridge design and will provide a 98% retention of particles whose size exceeds 3 microns.

Normally one of these two filters is in service and the other is in standby. Locating these filters upstream of the ion exchangers prevents excessive crud deposition, along with its associated radioactivity, in the ion exchangers.

5.2.9 Ion Exchangers

Three ion exchangers are incorporated into the design of the CVCS. Two of these ion exchangers function to purify the RCS by soluble ion removal while the third ion exchanger is used to reduce the RCS boron concentration.

Regardless of the ion exchanger's function, each ion exchanger is filled with millions of resin beads. Each resin bead consists of two principle parts; an inert, insoluble matrix, and a chemically active functional group. The matrix is a complex organic polymer that serves as an insoluble unit to which ions can be attached and thus be removed from solution. The functional group is exchanged for the ions that are removed from solution. Two different types of functional groups are required if both positive and negative ions are to be removed. The first type is called a cation and will replace metallic ions with hydrogen ions. The second functional group exchanges its hydroxide ion for negatively charged impurities and is called anion resin.

At high temperatures, the resin beads will lose their ability to remove impurities from the RCS and, in fact, may release the undesirable ions that were previously exchanged. Therefore, if letdown heat exchanger outlet temperature reaches 145°F, the ion exchangers are automatically bypassed by repositioning the ion exchanger inlet valve (CV-520). The boronometer and radiation monitor inlet valve (CV-521) must be manually repositioned after letdown temperature has been reduced to less than 145°F.

As previously stated, two different functions are performed by the ion exchangers. The purification function is performed by the two mixed bed ion exchangers. These ion exchangers contain anion and cation resin in a three to one ratio. The ion exchange process removes fission products to help maintain RCS activity within technical specification limits. The second function is to remove ions such as chlorides and fluorides which are responsible for RCS corrosion. One mixed bed is normally in service with the second unit in standby. The standby unit will be placed in service when the first unit loses its purification efficiency.

The deborating ion exchanger functions to reduce RCS boron concentration from 30 ppm to end of life concentrations. At low RCS boron concentrations, the dilution volume and the time required to change RCS boron concentration become excessive. The deborating ion exchanger contains only anion resin and directing letdown flow through this ion exchanger will reduce the RCS boron concentration.

Each ion exchanger tank contains internal resin bead retention elements; however, it is possible for broken beads (resin fines) to pass through the retention elements and into the letdown stream. Should this occur, the letdown strainer will collect the beads and prevent their entry into the volume control tank.

5.3 Volume Control Tank

The 3,880 gallon capacity VCT collects letdown and RCP CBO, provides a method of adding hydrogen to the RCS, interfaces with the Waste Processing System (WPS), interfaces with the reactor makeup system, and provides the normal suction source for the charging pumps.

5.3.1 Letdown Collection

Letdown flow into the volume control tank is governed by the volume control tank inlet valve (CV-500). The VCT inlet valve is a three way valve that has one inlet port and two outlet ports. The letdown is supplied through the inlet and normally passes through the outlet port that supplies the VCT. In this mode of operation, the letdown enters the VCT and is returned to the RCS by the charging pumps. However, should the level in the VCT exceed the high level setpoint (88%), the VCT inlet valve will direct the letdown stream to the waste processing system (WPS). When the VCT level decreases to less than 87%, letdown flow is returned to the VCT.

Two normal plant evolutions will cause a high level condition in the VCT. The first is a heatup of the RCS. As the RCS temperature is increased, volumetric expansion causes an increase in pressurizer level. In order to maintain pressurizer level in the desired band, the operator manually increases letdown flow. With constant charging flow and an increased letdown flow, VCT level rises causing the VCT inlet valve to direct letdown to the WPS. This operation will be repeated many times during the startup. The expansion of the RCS, due to a heat up from cold shutdown to hot standby, results in a 20,000 to 30,000 gallon influent into the WPS.

The second evolution that will cause an increase in VCT level is a large dilution of the RCS. During dilutions, the reactor makeup system supplies demineralized water to the VCT. This addition of water, combined with letdown flow, causes VCT level to rise. When the VCT inlet valve diverts, RCS water with a higher concentration is directed to the WPS while the charging pump(s) delivers water with a low boron concentration to the RCS. Large dilutions will be required to lower RCS boron concentration so that criticality can be achieved at the desired rod position, to compensate for the power coefficient as power is escalated to 100%, and to compensate for changes in xenon concentration.

In addition to collecting letdown, the VCT also receives the CBO flow from the RCPs. Individual bleed off lines are piped together and exit the containment building via redundant isolation valves (CV-505 and CV-506). The isolation valves are air-operated and are automatically closed by a SIAS. In the event of a SIAS, the CBO is diverted to the quench tank through relief valves.

5.3.2 Hydrogen and Waste Gas Interfaces

During power operations, the gas space of the VCT is pressurized with hydrogen which is absorbed by the incoming letdown flow. The coolant, containing the absorbed gas, is charged into the RCS where the radiation from the core causes the hydrogen to combine with free oxygen. The scavenging of free oxygen minimizes RCS corrosion. Hydrogen is added to the VCT from the plant hydrogen storage banks via a pressure regulating valve. Hydrogen pressure is maintained between 20-40 psig.

If maintenance is to be performed on the VCT during shutdown periods, the explosive hydrogen must be purged from the tank. This can be accomplished by venting the gas space of the VCT and adding nitrogen to purge out the hydrogen. This procedure must be reversed prior to startup because the addition of nitrogen to the RCS at power will cause the formation of corrosive nitric acid.

In addition to hydrogen, fission gases are found in the gas space of the VCT. These gases come out of solution as the letdown flows into the tank. The fission gases may be vented to the waste gas system by the operator.

5.3.3 Waste Processing System Interfaces

The automatic level diversion input into the WPS that was discussed in section 5.3.1 supplies an input of radioactive water to the WPS. The input of letdown into the WPS normally enters the vacuum degassifier where fission gasses are removed. The fission gases are piped to the waste gas system, and the water effluent from the vacuum degassifier is transferred to the RCS waste receiver tanks.

5.3.4 Charging Pump Suction Supply

The letdown that is collected in the VCT serves as a suction supply for the charging pumps. The VCT outlet valve (CVC-501) is located in the charging pump supply and receives two automatic control signals. First, the valve is interlocked closed on low-low VCT level (5.6%). At the same time, the charging pump suction supply valve (CVC-504) opens to supply a source of water from the Refueling Water Tank (RWT) to the charging pumps.

The VCT level interlock on these valves insures that a suction source is always available to the charging pumps. The VCT outlet valve also receives an automatic close signal from SIAS.

The piping between the VCT and the charging pump suction header contains penetrations from the concentrated boric acid storage tanks, the RWT, and the chemical addition tank.

5.3.5 Chemical Addition

The chemical addition tank has a capacity of eight gallons and is used to add lithium hydroxide or hydrazine to the RCS. Lithium hydroxide maintains the pH of the RCS in the basic region thus minimizing corrosion. Hydrazine is added to scavenge oxygen when the plant is in cold shutdown.

5.3.6 Relief Valves

Two relief valves are associated with the VCT and the charging pump suction header. A relief is installed on the gas space of the VCT and has a setpoint of 70 psig. The relief valve discharges to the plant vent header. The second relief is installed on the suction supply to the charging pumps and has a setpoint of 80 psig. This relief valve discharges to the waste receiver tank. Both relief valves are installed to prevent over pressure conditions in this section of the CVCS.

5.4 Charging System

The functions of the charging system are to return the purified coolant from the VCT to the RCS and to add coolant to the RCS during an accident. The suction for the charging pumps during an accident is the concentrated boric acid storage tanks.

5.4.1 Charging Pumps

Three positive displacement charging pumps are installed to perform the design functions of the charging system. Each pump has a capacity of 44 gpm and is motor driven. The 11 and 12 pumps are powered from their respective 480 Vac class 1E electrical distribution systems, while the 13 pump may be powered from either 480 Vac class 1E train.

The charging pumps are triple plunger pumps. Each plunger has a diameter of two and one-eight (2 1/8) inches and a stroke of five inches. The pump design pressure is 2800 psig, and the design temperature is 250°F. The pump is manufactured from 316 stainless steel. A 100 hp motor serves as the pump driver. Reduction gears reduce the speed of the motor to 210 rpm.

The charging pumps are equipped with a packing lubrication system that injects water into the packing area of the pump. This system consists of a small tank that gravity feeds the packing area and functions to extend the packing lifetime.

Pump discharge relief valves are installed to prevent shutoff operations of the positive displacement pumps. The valves are set at 2800 psig and have a capacity of 44 gpm.

During normal operations, only one pump is in service with the other two pumps in standby. The standby pumps are controlled by pressurizer level. If pressurizer level drops to a predetermined value, the first standby charging pump starts. If the increase in charging flow fails to stop the pressurizer level decrease, the second standby charging pump will start. A selector switch in the control room determines the order of charging pump operation. During emergency situations, all charging pumps are started by a SIAS signal. From the discharge of the charging pumps, the water flows to the shell side of regenerative heat exchanger.

5.4.2 Charging Supplies

The charging stream passes through the shell side of the regenerative heat exchanger where it is preheated to minimize the thermal shock to the RCS charging penetrations and then travels to the charging connections on the discharge of reactor coolant pumps 11A (CV-519) and 12B (CV-518) and, if required, to the auxiliary pressurizer spray line (CV-517).

The first two connections are normally open and return the coolant to the RCS. A spring-loaded check valve is in parallel with the charging supply to the discharge of RCP-11A (CV-519). The check valve insures that a discharge path for the charging pumps is always available.

The third connection is the auxiliary spray to the pressurizer and is used to decrease pressurizer pressure during cooldowns and other periods when the RCPs are not running. When auxiliary spray is used, the possibility of thermal shock exists. The temperature difference between the pressurizer and spray fluid is limited to 400°F by plant technical specifications. If the 400°F $\triangle$T limit is exceeded, then the value of $\triangle$T is logged and a total usage factor is maintained as a part of plant records. The spray to pressurizer $\triangle$T is computed by subtracting regenerative heat exchanger charging outlet temperature from pressurizer steam space temperature.

5.4.3 HPSI Check Valve Testing

A supply line from the common charging pump discharge to the high pressure safety injection (HPSI) system is provided to test the operability of the safety injection loop check valves. At normal operating pressures, the HPSI pump discharge pressure (~1400 psia) is too low to provide a flow through the check valves and into the RCS; therefore, the charging pumps may be used to provide the flow into the RCS. If one is able to obtain flow into the RCS with the charging pumps, the safety related check valve is open and can be considered operable.

5.5 Soluble Poison Control

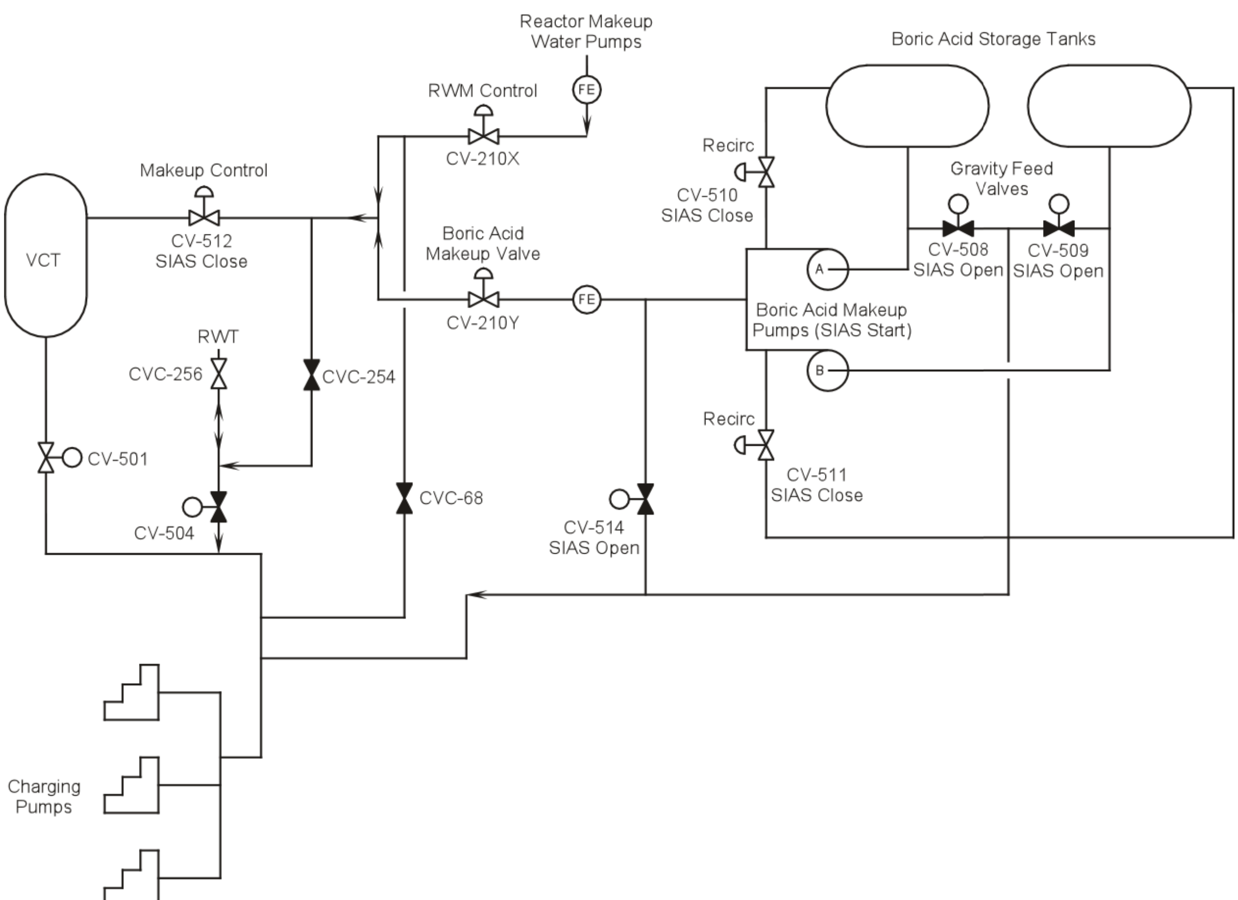

Figure 5-4 Makeup Control System

Boric acid is dissolved in the reactor coolant and is used for reactivity control. If negative reactivity additions are required, then the boron concentration is increased by the addition of boric acid. Conversely, the addition of pure water dilutes the RCS boron concentration and adds positive reactivity. Also, the compensation for VCT level changes due to normal leakage are made by the addition of both pure water and boric acid while maintaining a constant RCS boron concentration. These basic design requirements are satisfied by the boric acid and reactor makeup water systems.

5.5.1 Boric Acid System

The boric acid makeup system consists of two concentrated boric acid storage tanks, two boric acid pumps, and the necessary control valves for the addition of boric acid during emergencies and normal operations.

The concentrated boric acid storage tanks have a capacity of 9500 gallons and contain enough boric acid to ensure that 1% ΔK/K shutdown margin can be maintained if the plant is cooled down from normal operating conditions to less than 200°F and xenon free conditions exist at cold shutdown. The boric acid concentration in the tanks is approximately 12700 ppm.

Motor operated valves (CV-508 and CV-509) provide concentrated boric acid to the suction of the charging pumps. These gravity feed valves are automatically opened by a SIAS.

The tanks also supply concentrated boric acid to the CVCS via the boric acid pumps. The boric acid pumps are single-stage centrifugal pumps that are capable of supplying 143 gpm at design conditions. A recirculation flow of fluid through each pump is maintained at 10 gpm. The pumps are powered from the class 1E 480 Vac distribution system. Both pumps are started by a SIAS and discharge to the suction of the charging pumps through motor operated valve CV-514 which also receives a SIAS.

This path is redundant to the gravity feed path discussed earlier. The flow rate through either the gravity feed or pump discharge addition path is in excess of the 132 GPM requirement of three charging pumps. Recirculation valves (CV-510 and CV-511) are installed to provide a sufficient flowpath for the pumps in non-accident mode of operations. These valves are closed by a SIAS.

In addition to the accident supply, the boric acid pumps supply boric acid to the CVCS for soluble poison concentration control. The boric acid flow control valve (CV-210Y) supplies boric acid to the VCT via the makeup stop valve (CV-512). The boric acid flow control valve will open in the borate or automatic modes of the makeup mode selector switch.

The boric acid addition rate (30 gpm maximum) in the borate mode of operation will result in a 6 ppm/minute rate of change of RCS boron concentration. Certain transients and accidents require a faster rate of change of boron concentration. An anticipated transient without scram (ATWS) is an example of such a situation. An ATWS is caused by some common mode failure that prevents the reactor protection system (RPS) from inserting the CEAs when a valid trip condition exists. Since the CEAs cannot shut down the reactor, boric acid must be used. If an ATWS occurs, the plant operators will add boric acid via the gravity feed valves or through CV-514. The rate of change of RCS boric acid concentration in this mode of operation is approximately 26 ppm/minute.

5.5.2 Demineralized Water Supply

The demineralized water supply consists of a supply of demineralized water from the demineralized water system, reactor coolant makeup water pumps (RCMU pumps), and associated valving. The demineralized water tank is a 350,000 gallon capacity tank that is filled by the plant makeup demineralizers and serves as the storage reservoir for reactor makeup water.

The RCMU pumps are motor-driven, single stage centrifugal pumps that supply reactor makeup water to the CVCS. Since the ability to dilute the RCS is not safety related, the reactor makeup water pumps are powered from non-vital 480 Vac.

The reactor makeup flow control valve (CV-210X) supplies demineralized water to the VCT via the makeup stop valve (CV-512). The reactor makeup flow control valve will open in the dilute or automatic modes of the makeup mode selector switch.

5.5.3 Makeup Control System

The makeup control system contains a mode selector switch, flow controllers, batch controllers, and the control valves described in Sections 5.5.1 and 5.5.2. The mode control switch is a four position selector switch that is located in the control room and determines the position of the control valves in the makeup system. Two flow controllers are provided to determine the addition rates of boric acid and reactor makeup water by controlling the position of boric acid flow control valve (CV-210Y) and reactor makeup flow control valve (CV-210X).

When a dilution or boration is to be performed, the operator sets in the desired quantity into the batch controllers. As the fluid passes through the flow elements, a signal is also sent to the batch controllers. When the quantity of added solution equals the operator's setpoint, the boration or dilution is terminated by the batch controllers. The batch controllers along with the flow controllers and mode selector switch provide signals to the control valves in the makeup system.

The operation of these devices will be described by discussing the borate, dilute, auto and manual positions of the mode selector switch .

1. In the borate position of the mode selector, boric acid flow control valve (CV-210Y) will open to supply concentrated boric acid to the VCT via the makeup stop valve (CV-512). To borate, the operator selects an addition rate, a batch size, opens the makeup stop valve, and positions the mode selector switch to the borate position. The selected boric acid pump will start, CV-210Y will control the addition rate of boric acid into the system. When the quantity of boric acid equals the batch size placed into the boric acid batch controller, CV-210Y closes and the boric acid pump stops.

2. In the dilute position of the mode selector, the reactor makeup flow control valve (CV-210X) and makeup stop valve CV-512 open to supply demineralized reactor makeup water to the VCT. To dilute, the operator selects an addition rate, a batch size, and positions the mode selector switch to the dilute position. The selected reactor makeup water pump will start, CV-210X will control the addition rate of reactor makeup water, and CV-512 will be

manually opened to complete the flowpath to the VCT. When the batch has been added, the reactor makeup water batch controller will close reactor makeup flow control valve (CV-210X) and stop the reactor makeup water pumps. The makeup stop valve will be manually closed.

3. In the auto position of the mode selector, VCT level controls the makeup system. If VCT level decreases to 72%, the makeup system will restore the level to 86%. This evolution is accomplished by opening CV-210X, CV-210Y, CV-512, and sending a start to the boric acid and RCMU pumps. The concentration of the added solution is determined by the flow controller settings for boric acid and reactor makeup water.

4. The manual position of the mode selector allows the manual control of any control valve in the makeup system. Manual mode is normally used during makeup of the RWT.

5.6 Engineered Safety Features

Operations

The changes that occur in the CVCS upon the receipt of an engineered safety features signal are:

1. Letdown is isolated,
2. The VCT outlet valve is closed,
3. All three charging pumps start,
4. Both boric acid pumps start,
5. The gravity feed addition valves open,
6. The boric acid discharge valve (CVC-514) opens to direct the discharge of the boric acid pumps to the charging pump suction,
7. Boric acid pump recirculation valves close and
8. RCP CBO valves close.

The above actions isolate the non-vital letdown line and inject concentrated boric acid into the RCS via the normal charging paths; however, safety analysis does not take credit for the addition of the CVCS during accidents. Operator actions are required to stop the boric acid makeup and charging pumps prior to emptying the concentrated boric acid storage tanks.

5.7 Summary

The CVCS is a major auxiliary system that functions to control RCS inventory, to maintain RCS chemistry, and to control the soluble poison concentration of the RCS. In addition, the CVCS supplies borated water to the RCS in the event of an accident.

Major system interfaces include the pressurizer level control system which varies letdown or charging flow based upon pressurizer level error, the WPS which receives its influent from the letdown system, and the makeup system that provides methods of soluble poison control.

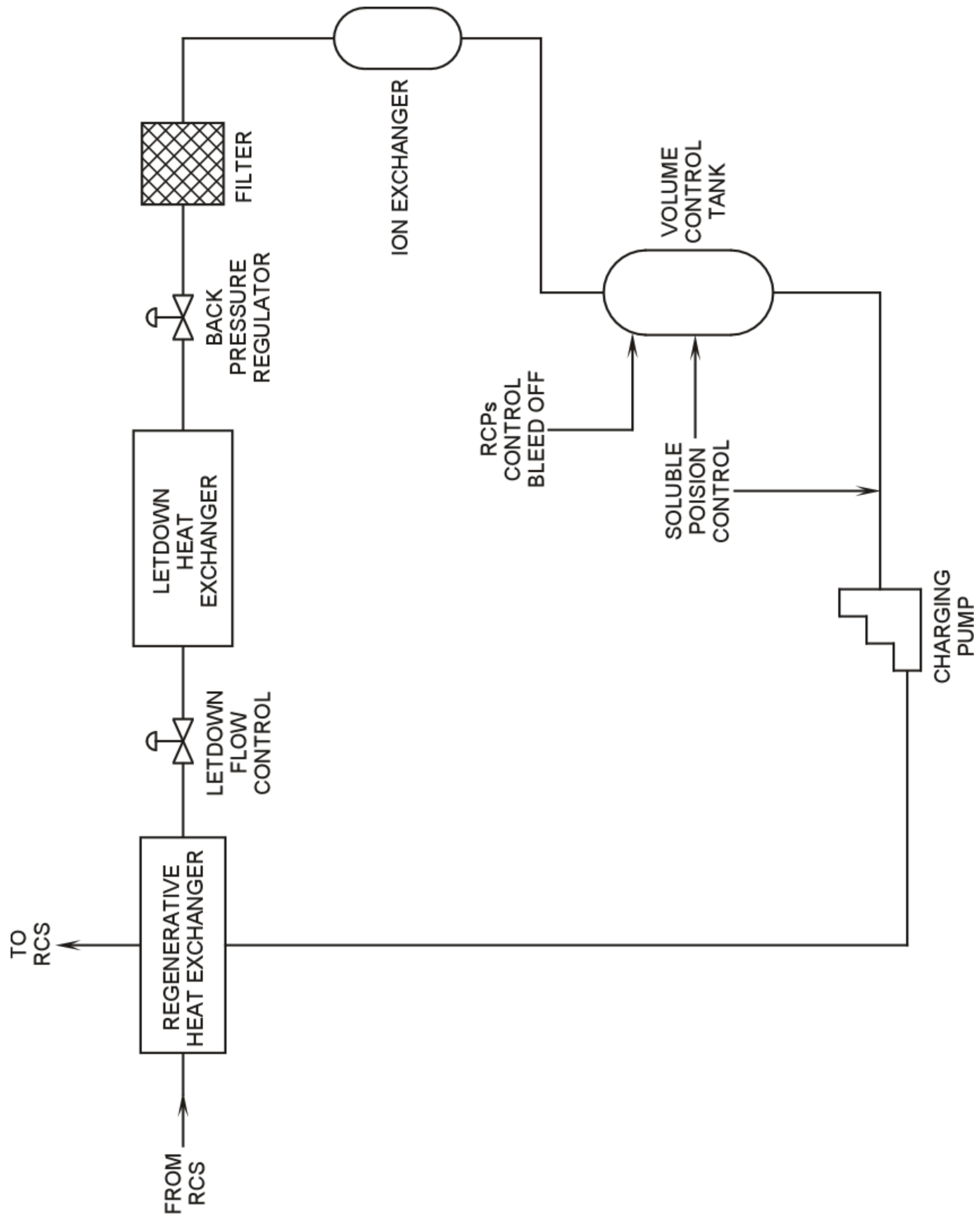

Figure 5-1 Simplified Chemical and Volume Control System

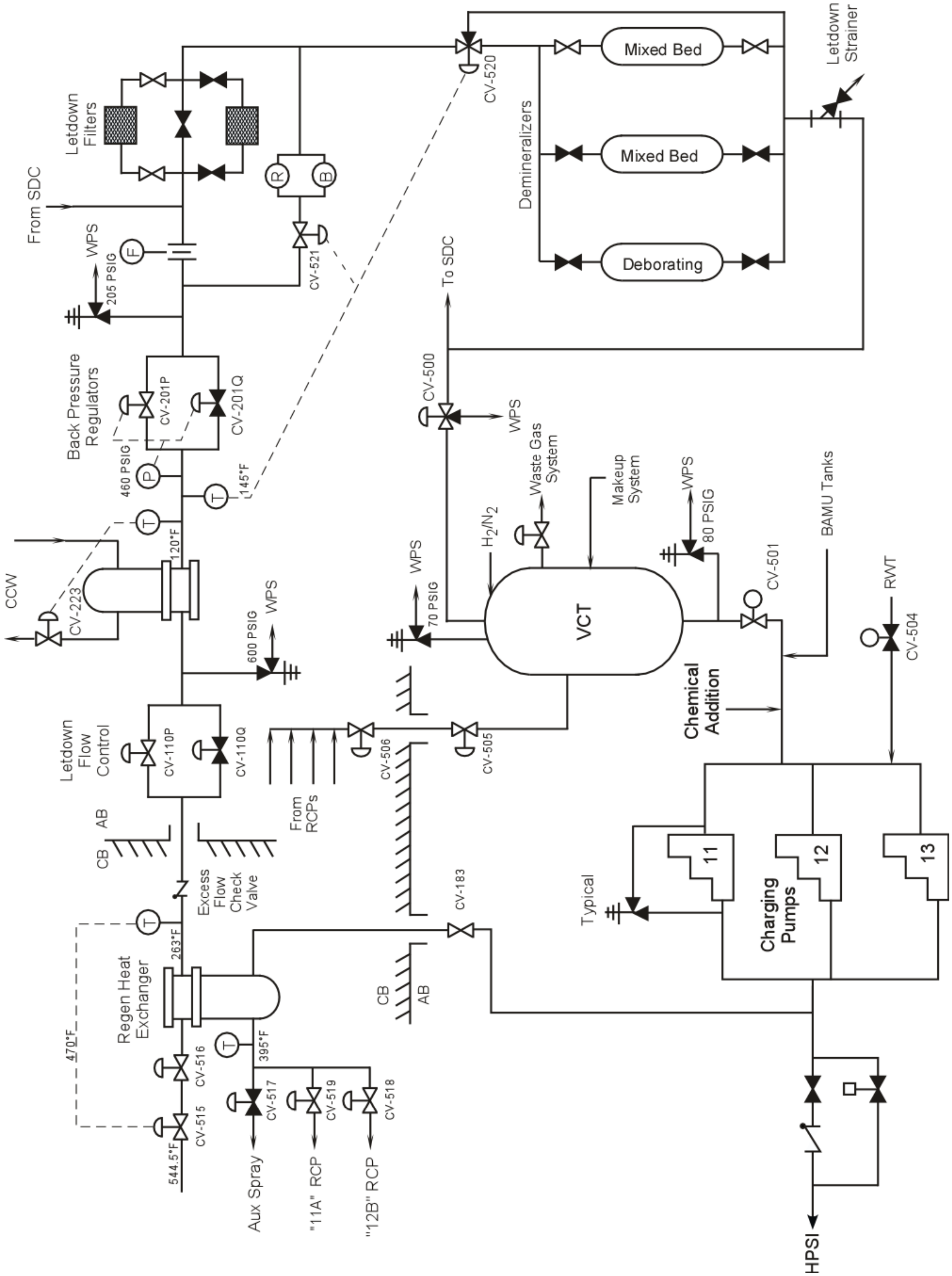

Figure 5-2 CVCS Diagram

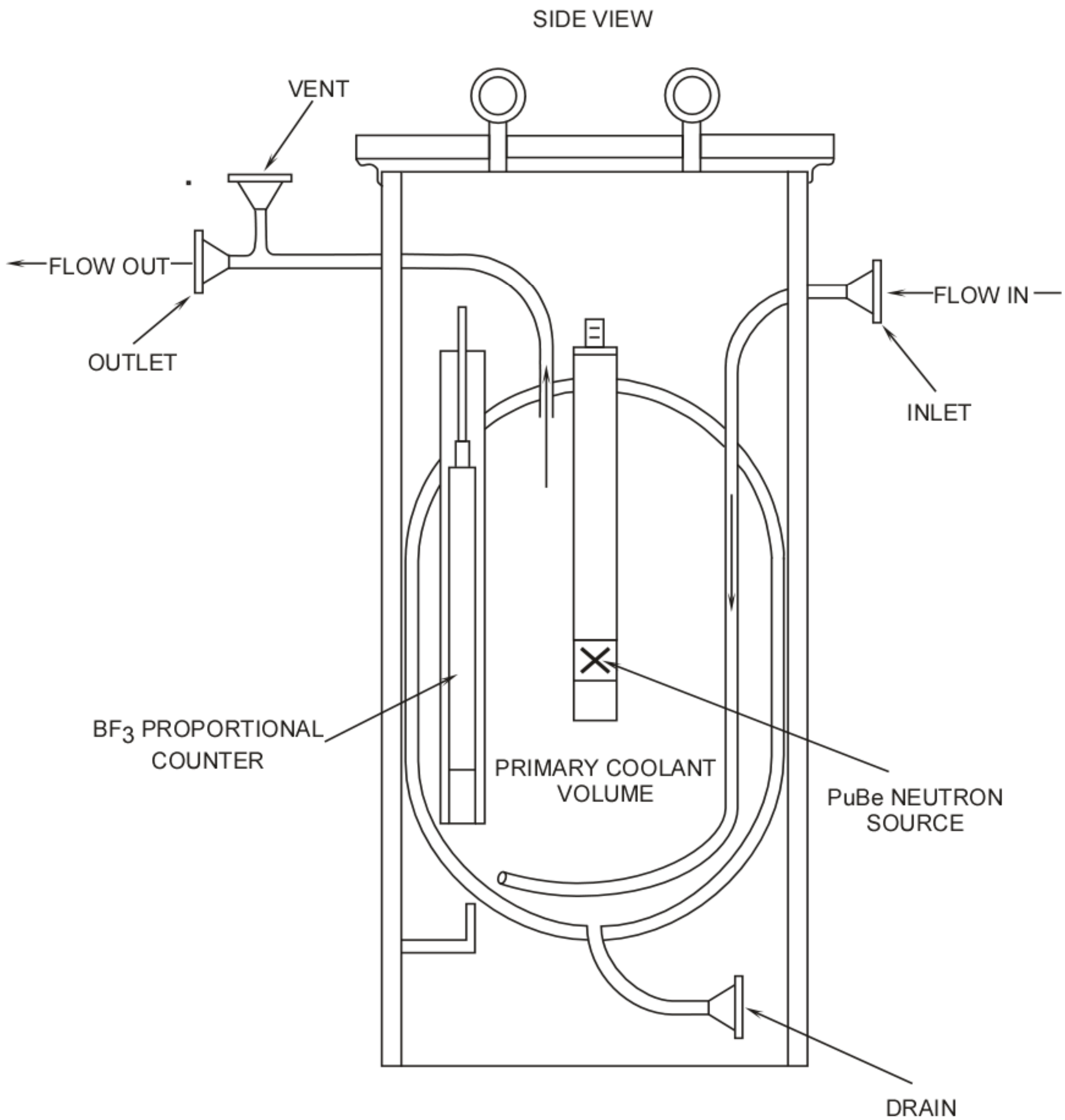

Figure 5-3 Boronometer Assembly

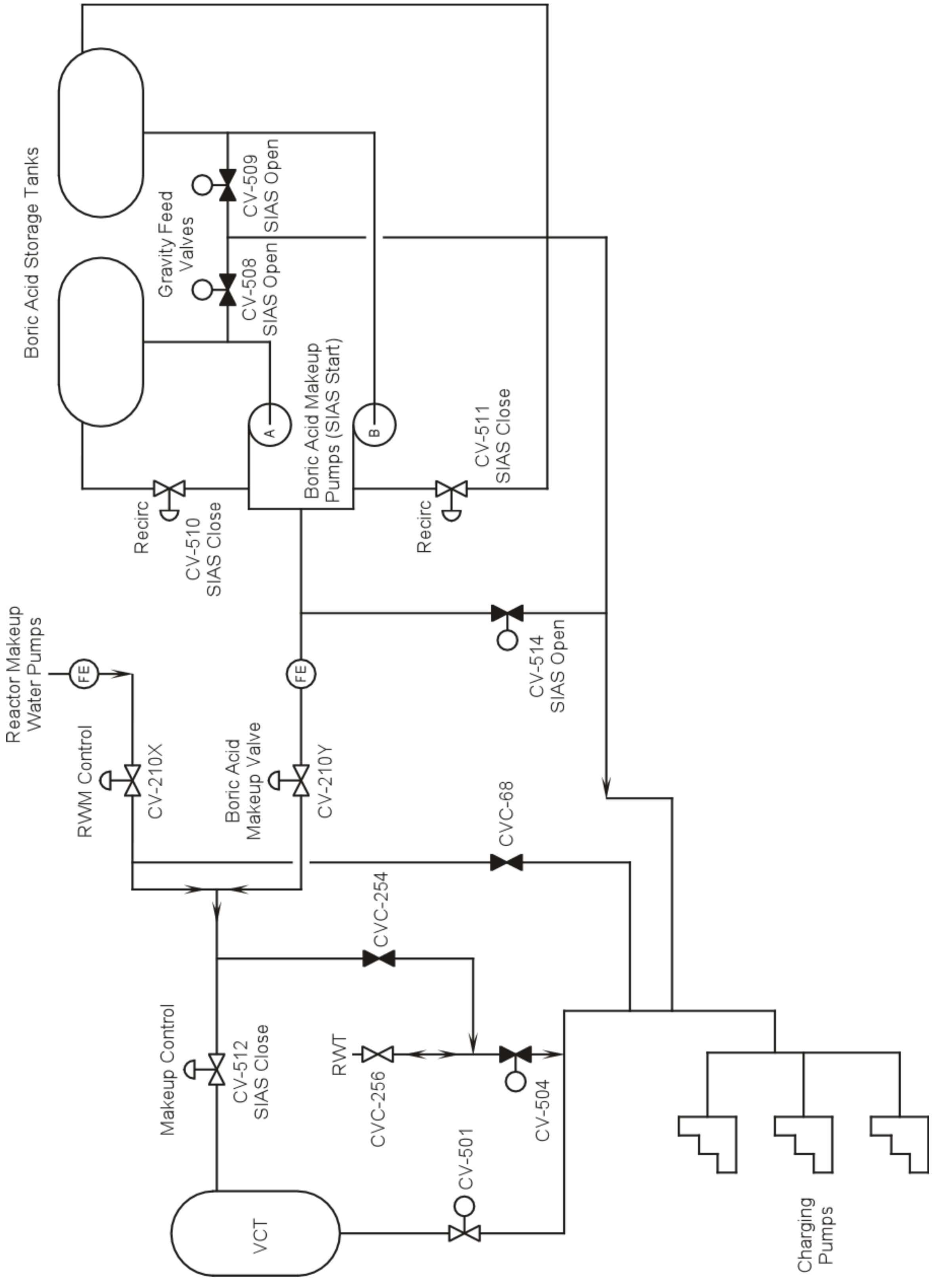

Figure 5-4 Makeup Control System