# CHAPTER 9 AUXILIARY AND EMERGENCY SYSTEMS

## 9.1 CHEMICAL AND VOLUME CONTROL SYSTEM

### 9.1.1 DESIGN BASES

The Chemical and Volume Control System maintains the proper water inventory in the Reactor Coolant System, provides the required seal water flow for the reactor coolant pump shaft seals, adjusts the concentration of chemical neutron absorber, reduces the quantity of fission product and corrosion product impurities, processes reactor coolant effluent for reuse of boric acid and demineralized water, and maintains the proper concentration of corrosion inhibiting chemicals in the reactor coolant. The system is also used to hydrostatically test the Reactor Coolant System.

System integrity is assured by conformance to applicable ASME Vessel and ASA Pressure Piping Codes listed in Table 9-1 and by use of austenitic stainless steel or other corrosion resistant materials in contact with both reactor coolant and boric acid solutions.

TABLE 9-1

CHEMICAL AND VOLUME CONTROL SYSTEM CODE REQUIREMENTS

| | |
|---|---|
| Regenerative heat exchanger | ASME III*, Class A |
| Mixed bed demineralizers | ASME III, Class C |
| Reactor coolant filter | ASME III, Class C |
| Volume control tank | ASME III, Class C |
| Seal water heat exchanger (tube side) | ASME III, Class C |
| Seal water filter | ASME III, Class C |
| Excess letdown heat exchanger (tube side) | ASME III, Class C |
| Boric acid filter | ASME III, Class C |
| Chemical addition tank | ASME VIII |
| Piping and valves | ASA-B31.1**, Section 1 |
| Non-regenerative heat exchanger (tube side) | ASME III, Class C |

* ASME III - American Society of Mechanical Engineers, Boiler and Pressure Vessel Code, Section III, Nuclear Vessels.

** ASA-B31.1 - Code for Pressure Piping, American Standards Association, and special nuclear cases, where applicable.

## 9.1.2 SYSTEM DESIGN AND OPERATION

Flow diagrams of the Chemical and Volume Control System are shown in Figures 9-1, 9-2 and 9-3.

During plant operation, reactor coolant flows from a cold leg of the Reactor Coolant System and is returned to one hot leg and one cold leg via the charging lines. Each of the connections to the Reactor Coolant System have an isolation valve located close to the loop piping. In addition, a check valve is located downstream of each charging line isolation valve. The reactor coolant entering the Chemical and Volume Control System is cooled in the shell side of the regenerative heat exchanger and its pressure is then reduced in passing through one of the letdown orifices. The cooled, low pressure water leaves the reactor containment and flows through the non-regenerative heat exchanger where the temperature is further reduced. On leaving the non-regenerative heat exchanger, the coolant undergoes a second pressure reduction and then passes through a mixed bed demineralizer where ionic impurities are removed. The coolant then passes through a filter and flows through a spray nozzle into the volume control tank. The atmosphere in this tank contains hydrogen which dissolves in the reactor coolant. Prior to a cold or refueling shutdown, fission gases are removed from the coolant and are vented from the volume control tank to the Waste Disposal System. Next, the coolant flows to the charging pumps which raise the pressure above that in the Reactor Coolant System. The coolant then enters the reactor containment, passes through the tube side of the regenerative heat exchanger, and returns to the Reactor Coolant System via a charging line.

A portion of the high pressure charging flow is injected into the reactor coolant pumps between the pump impeller and the shaft seal so that the seals are not exposed to high temperature reactor coolant. Part of the flow cools the lower radial bearing and enters the Reactor Coolant System through a labyrinth seal on the pump shaft. The remainder, which is the shaft seal leakage flow, is filtered, cooled in the seal water heat exchanger and returned to the volume control tank. Coolant injected through the reactor coolant pump labyrinth seals returns to the volume control tank by the normal letdown flow path through the regenerative heat exchanger. When the normal letdown route is not in service, labyrinth seal injection flow return to the volume control tank through the excess letdown and seal water heat exchangers.

During plant startup, normal operation and shutdowns, liquid effluent from the Reactor Coolant System will be collected in the holdup tanks. Reactor coolant letdown flow is diverted to the holdup tanks by a high level signal from the volume control tank. The gas space in the holdup tanks is filled with nitrogen at a low pressure to prevent accumulation of a potentially explosive mixture of hydrogen and oxygen. As liquid enters the tanks, the cover gas is displaced to the gas decay tanks through the vent header. For convenience, a recirculation pump is provided to transfer liquid from one tank to another.

Liquid from a holdup tank, which is essentially dilute boric acid, is processed as a batch operation and is pumped initially through base and cation ion exchangers to remove radioactive containments and some fission products and then through the preheater and into the gas stripper where dissolved gases are stripped from the liquid. The effluent from the gas stripper is fed to the boric acid evaporator where the dilute boric acid solution is concentrated.

Vapor from the boric acid evaporator flows through a condenser where it is cooled to the operating temperature of the evaporator condensate demineralizer. After any evaporator carryover is removed by one of the two evaporator condensate demineralizers, condensate passes through a condensate filter and then accumulates in the monitor tanks.

Subsequent handling is dependent on the results of sample analysis. Discharge from the monitor tanks may be: pumped to the primary water storage tank, recycled through the demineralizers, returned to the holdup tanks for reprocessing in the evaporator train, or released to the waste disposal system for discharge to the environment via the main condenser cooling water, if the sample analysis of the monitor tank contents indicates that they may be discharged safely to the environment, two valves must be opened to provide a discharge path. As the effluent leaves it will be continuously monitored and if an unexpected increase in radioactivity is sensed, one of the discharge valves will be closed automatically by a signal from the monitor.

Boric acid evaporator bottoms may be discharged to the concentrates holding tank via a concentrates filter. Solution collected in the concentrates holding tank is sampled and then transferred to one of the boric acid tanks if analysis indicates that it meets specifications for use as boric acid makeup. Otherwise, concentrates are returned to the holdup tanks for reprocessing by the evaporator train.

The concentrated solution can also be drained from the boric acid evaporator to the drumming station where it is placed in containers with a solidifying agent. These containers can then be stored at the plant site for ultimate shipment off site for disposal.

Makeup to the Reactor Coolant System is provided by the Chemical and Volume Control System from the following sources:

a) The primary water storage tank, which provides demineralized water for dilution when the reactor coolant boron concentration is to be reduced.

b) The boric acid tanks, which supply concentrated boric acid solution when reactor coolant boron concentration is to be increased.

c) The refueling water storage tank which supplies borated water for emergency makeup and refueling.

d) The chemical addition tank, which is used to inject small quantities of solution when additions of hydrazine or pH control chemicals are necessary.

Makeup for normal plant leakage is provided by the reactor makeup control which is set by the operator to blend demineralized water and concentrated boric acid to match the reactor coolant boron concentration. Makeup is added automatically if the volume control tank level falls below a preset point.

## 9.1.3 COMPONENTS

### 9.1.3.1 Regenerative Heat Exchanger

The regenerative heat exchanger recovers heat from the reactor coolant letdown stream by heating the charging stream. The letdown coolant passes through the shell side while the charging stream flows through the tubes of the exchanger. The unit is a multiple shell unit constructed from austenitic stainless steel with the shell and heads of welded construction. The tubes are welded to the tube sheet.

### 9.1.3.2 Letdown Orifices

Three letdown orifices control the rate of letdown flow from the Reactor Coolant System and reduce the coolant pressure. Each orifice is placed in and taken out of service by remote operation of an isolation valve. Normally, one orifice is operating while the others serve as standbys. The orifice bodies and trim are constructed of austenitic stainless steel or equivalent corrosion resistant material.

#### 9.1.3.3 Non-Regenerative Heat Exchanger

The non-regenerative heat exchanger cools the letdown stream to the operating temperature of the mixed bed demineralizers. Letdown flows through the tube side of the exchanger while component cooling water flows through the shell. The unit is a multiple pass "U" tube and shell heat exchanger. All surfaces in contact with the reactor coolant are austenitic stainless steel, and the shell is carbon steel. The tubes are welded to the tube sheet.

#### 9.1.3.4 Mixed Bed Demineralizers

Two flushable, mixed bed demineralizers maintain reactor coolant water purity. A strong base or ammonia form cation resin and a hydroxyl form anion resin are initially charged into the demineralizer. The anion resin is converted to the borate form by contact with the borated reactor coolant. A retention screen beneath the resin bed prevents the loss of resin particles to the outlet line. One of the units is normally in service with the other providing full standby capacity. The demineralizer vessels are made of austenitic stainless steel.

#### 9.1.3.5 Cation Bed Demineralizer

One flushable cation bed demineralizer is installed capable of accepting a portion of the letdown flow. Hydrogen form ion exchange resin is employed to remove and control the cesium and lithium concentrations in the reactor coolant system.

#### 9.1.3.6 Resin Fill Tank

A conically shaped, austenitic stainless steel resin fill tank is provided to prepare and sluice fresh resin slurry into the demineralizers.

### 9.1.3.7 Reactor Coolant Filter

The filter collects resin fines and particulate matter larger than 25 microns. This filter design utilizes a replaceable cage assembly which contains synthetic fiber cartridges. These cage assemblies may be replaced locally or remotely. Individual cartridges or complete cage may be changed. The filter shells are constructed of all-welded austenitic stainless steel.

### 9.1.3.8 Volume Control Tank

The volume control tank collects excess water released from the Reactor Coolant System when the power level is increased from zero power to full power. Hydrogen pressure is maintained over the water in the volume control tank to control the hydrogen concentration in the reactor coolant water.

A spray nozzle located in the tank on the inlet line from the reactor coolant filter provides intimate contact between the gas and liquid phases. A remotely operated vent valve discharging to the Waste Disposal System permits removal of gaseous fission products which are stripped from the reactor coolant and collect in this tank. The volume control tank also acts as a head tank for the charging pumps. The tank is constructed of austenitic stainless steel.

### 9.1.3.9 Charging Pumps

Three charging pumps inject coolant into the Reactor Coolant System and reactor coolant pump shaft seals. Normally one pump is operating while the others serve as standby and additional capacity for certain plant operations. The pumps are the variable speed, positive displacement type with all parts in contact with the reactor coolant fabricated of austenitic stainless steel or equivalent corrosion resistant material. Stuffing box leakoffs are piped to the Waste Disposal System to prevent leakage of reactor coolant.

### 9.1.3.10 Seal Water Heat Exchanger

The seal water heat exchanger cools the reactor coolant pumps shaft seal leakoff flow and the discharge from the excess letdown heat exchanger. The unit is a shell and tube heat exchanger with seal leakage on the tube side and component cooling water on the shell side. The tubes and other surfaces in contact with reactor coolant are austenitic stainless steel, and the shell is carbon steel. Tubes are welded to the tube sheet.

### 9.1.3.11 Boric Acid Transfer Pumps

Two canned motor centrifugal pumps circulate boric acid solution through the boric acid tanks and boric acid filter and inject boric acid into the charging pump suction header. All piping associated with the transport of concentrated boric acid are heat traced.

Either pump may function as standby for the other. All parts in contact with the solution are austenitic stainless steel or other material suitable for boric acid service.

### 9.1.3.12 Boric Acid Tanks

Boric acid solution recovered from the recycle processing train or mixed in the batching tank is stored in the boric acid tanks. One tank supplies boric acid for reactor coolant makeup while recycled solution from the concentrates holding tank is being accumulated in the second tank. The tanks are heated by electric immersion heaters. The concentration of boric acid solution used for makeup to the reactor coolant is maintained essentially constant by periodic manual sampling and corrective action. The concentration of recycle solution is determined by sampling of the concentrates holding tank and corrected as required before storage in the boric acid tanks. The tanks are constructed of austenitic stainless steel.

### 9.1.3.13 Chemical Addition Tank

The chemical addition tank is used to inject chemical solution into the reactor coolant system. Its chief use is the addition of caustic solutions for reactor coolant pH control and hydrazine for oxygen scavenging. The chemical addition tank is austenitic stainless steel.

### 9.1.3.14 Excess Letdown Heat Exchanger

The excess letdown heat exchanger provides a letdown flow path for coolant charged through the reactor coolant pump labyrinth seals if the normal letdown path through the regenerative heat exchanger is out of service. The high pressure letdown stream flows through the tubes while component cooling water flows through the shell. The tubes and tube sheet are austenitic stainless steel, and the shell is carbon steel. Tubes are welded to the tube sheet.

### 9.1.3.15 Batching Tank

The batching tank is used to mix boric acid solution for the boric acid tanks. The tank may also be used for solution storage. A local sampling point is provided for tank drainage and for checking the solution concentration prior to transferring to the boric acid tank. The batching tank is constructed of austenitic stainless steel with a carbon steel, steam jacketed lower head.

### 9.1.3.16 Electric Heaters

Two electric immersion heaters in each boric acid tank and the concentrates holding tank maintain the temperature of the acid at a level sufficient to ensure solution. The heaters are sheathed in austenitic stainless steel.

### 9.1.3.17 Holdup Tanks

Three holdup tanks retain radioactive liquids. The contents of one tank are normally being processed by the gas stripper and boric acid evaporator while another tank is being filled. The third tank is normally kept empty to provide additional storage capacity if required. The tanks are stainless steel of welded construction.

### 9.1.3.18 Gas Stripper

The gas stripper removes dissolved gases from the borated water. The stripper consists of a hot well to store stripped water, a stripping section packed with pall (or similar) rings, a spray type liquid inlet header and an overhead integral reflux condenser. The stripper is made of all-welded austenitic stainless steel. Liquid fed to the gas stripper is automatically maintained at a constant rate by a flow controller. Liquid flows from the gas stripper to the boric acid evaporator by gravity.

### 9.1.3.19 Boric Acid Evaporator

The Boric Acid evaporator produces concentrated boric acid solution from the dilute boric acid feed on a semi-batch type basis. The boric acid evaporator package is a pre-assembled skid mounted unit. The evaporator package contains a feed tank, feed pumps, condenser, condensate storage pumps, piping and instrumentation.

The feed stream is concentrated using a low temperature, high vacuum evaporator process. Effluent from the feed tank is pumped into the evaporator where boiling takes place. The bottoms are continuously recycled back to the feed tank until the solution is concentrated to approximately 12% boric acid.

A series of demisters which remove aerosols from the steam are located above the U tube evaporator. Steam flows from the evaporator section to the condenser. The entire evaporator package is austenitic stainless steel.

### 9.1.3.20 Deborating Demineralizers

Two anion demineralizers remove boric acid from the reactor coolant letdown flow through the Chemical and Volume Control System. They normally are used near the end of a core cycle, but can be used at any time. Hydroxyl form ion-exchange resin is used. Facilities are provided for regeneration of the resin whenever necessary. When regeneration is unsuccessful, the resin is flushed to the spent resin storage tank. The demineralizer vessels are made of all-welded austenitic stainless steel.

### 9.1.3.21 Boric Acid Evaporator Condensate Demineralizer

Two anion demineralizers using hydroxyl form resin remove boric acid carry over and negatively charged fission products contained in the boric acid evaporator condensate. Facilities are provided for regeneration of the resin whenever necessary. When regeneration is unsuccessful, the resin is flushed to the spent resin storage tank. The demineralizer vessels are made of all-welded austenitic stainless steel.

### 9.1.3.22 Condensate Filter

The filter collects resin fines and particulate matter larger than 25 microns. This filter design utilizes a replaceable cage assembly which contains synthetic fiber cartridges. These cage assemblies may be replaced locally or remotely. Individual cartridges or complete cage may be changed. The filter shells are constructed of all-welded austenitic stainless steel.

### 9.1.3.23 Monitor Tanks

Two tanks collect boric acid evaporator condensate. Approximately once a day the contents are sampled and analyzed for radioactivity and purity. If the water is of sufficient purity and low in radioactivity, it may be transferred to the primary water storage tank for reuse by the primary plant or to the waste disposal system for discharge. When purity is low and radioactivity is high, the water is returned to the holdup tanks or evaporator condensate demineralizers for reprocessing. The monitor tanks are all-welded carbon steel lined with a suitable protective coating and a flexible membrane to prevent aeration of the condensate.

### 9.1.3.24 Concentrates Holding Tank

The concentrates holding tank retains the evaporator concentrates for sampling and analysis. The concentrates are then pumped to the boric acid tanks or to the holdup tanks. The tank is constructed of austenitic stainless steel and is heated with electric immersion heaters.

### 9.1.3.25 Base Removal Ion Exchangers

Two cation demineralizers, installed in parallel, remove the base ions from the gas stripper feed to permit the subsequent removal of any cesium and molybdenum isotopes present. Hydrogen form ion exchange resin is used. Spent resin is flushed to the spent resin storage tank. The ion exchange vessels are made of all-welded austenitic stainless steel.

### 9.1.3.26 Cation Removal Ion Exchanger

Two cation demineralizers, installed in parallel, remove any cesium and molybdenum isotopes after the base has been removed. Hydrogen form ion exchange resin is used. Spent resin is flushed to the spent resin storage tank. The ion exchange vessels are made of all-welded austenitic stainless steel.

### 9.1.3.27 Concentrate Filters

A filter, with a bypass is provided to remove particulate matter from the evaporator concentrates. The construction is from stainless steel with a disposable synthetic fiber cartridge filter element.

### 9.1.3.28 Pumps

Pumps used throughout the recycle processing train are as follows:

a) Two gas stripper feed pumps
b) Two boric acid evaporator condensate pumps
c) Two monitor tank drain pumps
d) One holdup tank recirculation pump
e) Two concentrates holding tank transfer pumps
f) Two boric acid evaporator concentrates transfer pumps
g) Two gas stripper bottoms pumps

The wetted surfaces of all pumps are stainless steel or other materials of equivalent corrosion resistance.

### 9.1.3.29 Valves

Valves that perform a modulating function are equipped with two sets of packing and an intermediate leakoff connection that discharges to the Waste Disposal System. All other valves have stem leakage control. Normally, globe valves are installed with pressure under the seat to prevent leakage through the packing when the valve is closed, however, in certain cases pressure is applied above the seats when such an arrangement reduces the possibility of leakage of radioactive fluids.

Stop valves are provided to isolate all connections to the Reactor Coolant System. Lines entering the reactor containment also have check valves to prevent reverse flow from the containment.

Relief valves are provided for lines and components that might be pressurized above design pressure by improper operation or component malfunction. Pressure relief for the tube side of the regenerative heat exchanger is provided by the spray line isolation valve which is designed to open when pressure under the seat exceeds reactor coolant pressure by 250 psi.

9.1.3.30 Piping

All Chemical and Volume Control System piping is austenitic stainless steel except for the steam supply lines. All piping joints and connections are welded, except where flanged connections are required to facilitate equipment removal for maintenance and hydrostatic testing. Piping, valves, equipment and line-mounted instrumentation, which normally contain concentrated boric acid solution, are heated by electrical tracing to ensure solubility of the boric acid.

## 9.2 AUXILIARY COOLANT SYSTEM

### 9.2.1 DESIGN BASES

The Auxiliary Coolant System removes residual and sensible heat from the Reactor Coolant System during plant shutdown, cools the spent fuel pit water, removes heat from the Waste Disposal System, cools the letdown flow in the Chemical and Volume Control System during power operation and provides cooling to dissipate waste heat from various primary plant components.

All piping and components of the Auxiliary Coolant System are designed to the applicable codes and standards listed in Table 9-2. The component cooling loop water contains a corrosion inhibitor to protect the carbon steel piping. Austenitic stainless steel piping is used in the residual heat removal loop, which contains reactor coolant, and in the spent fuel pit cooling loop, which contains water without inhibitor.

TABLE 9-2

AUXILIARY COOLANT SYSTEM CODE REQUIREMENTS

| | |
|---|---|
| Component Cooling Heat Exchangers | ASME VIII* |
| Component Cooling Surge Tank | ASME VIII |
| Component Cooling Loop Piping and Valves | ASA B31.1**, Section 1 |
| Residual Heat Exchangers | ASME III***, Class C |
| Residual Heat Removal Piping and Valves | ASA B31.1, Section 1 |
| Spent Fuel Pit Heat Exchanger | ASME III, Class C |
| Spent Fuel Pit Filter | ASME III, Class C |
| Spent Fuel Pit Loop Piping and Valves | ASA B31.1, Section 1 |

The auxiliary Coolant System provides cooling for the following components and systems:

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* ASME Boiler and Pressure Vessel Code, Section VIII, Unfired Pressure Vessels

** ASA B31.1, Code for Pressure Piping and Special Nuclear Cases where applicable

*** ASME Boiler and Pressure Vessel Code, Section III, Nuclear Vessels

a) The seal water heat exchanger
b) The excess letdown heat exchanger
c) The sample heat exchangers
d) The residual heat exchangers
e) The non-regenerative heat exchanger
f) The spent fuel pit heat exchanger
g) The reactor coolant pumps
h) The Waste Disposal System
i) The residual heat removal pumps
j) Gas stripper package and boric acid evaporator package (CVCS)

The Auxiliary Coolant System consists of three loops: the Component Cooling Loop, the Residual Heat Removal Loop and the Spent Fuel Pit Cooling Loop as shown on Figure 9-4.

### 9.2.2 SYSTEM DESIGN AND OPERATION

#### 9.2.2.1 Component Cooling Loop

The Component Cooling Loop removes heat from the residual, spent fuel pit, seal water, non-regenerative, excess letdown and sample heat exchangers, the residual and reactor coolant pumps, the gas stripper and boric acid evaporator packages, and Waste Disposal System. Component cooling water flows through these units in parallel flow circuits, picks up heat from the various components, and flows to the component cooling heat exchangers which are cooled by service water. The component cooling loop thus serves as an intermediate system between the reactor coolant and the service water systems. This double barrier arrangement reduces the probability of leakage of high pressure, potentially radioactive coolant to the service water system.

During normal full power operation, one component cooling pump and one component cooling heat exchanger accommodate the heat removal loads. Two standby pumps and a heat exchanger provide 100 per cent backup during normal operation. Three pumps and two heat exchangers are utilized to remove the residual and sensible heat during plant shutdown. If one of the pumps or one of the heat exchangers is not operative, orderly shutdown is not affected; only the time for cooldown is extended.

Component cooling water circulated through the reactor coolant pumps removes heat from the bearing oil and the thermal barrier. The surge tank accommodates expansion, contraction and in-leakage of water and ensures a continuous component cooling water supply until a leaking cooling line can be isolated. Because the tank is normally vented to the atmosphere, a radiation monitor in the component cooling pump inlet header annunciates in the control room and closes a valve in the vent line in the unlikely event that the radiation level reaches a preset level above the normal background.

9.2.2.2 Residual Heat Removal Loop

During the first phase of shutdown, the temperature of the Reactor Coolant System is reduced by transferring heat from the Reactor Coolant System to the steam generators. The residual heat removal loop removes residual heat from the core and reduces the temperature of the Reactor Coolant System during the second phase of plant cooldown. The Residual Heat Removal Loop is also used during Safety Injection and core cooling and its function in that capacity is described in Chapter 6.

The Residual Heat Removal loop consists of heat exchangers, pumps, piping and the necessary valves and instrumentation. During plant shutdown, coolant flows from the Reactor Coolant System to the residual heat removal pumps, through the tube side of the residual heat exchangers and back to the Reactor Coolant System. The inlet line to the Residual Heat Removal Loop starts at the hot leg of one reactor coolant loop and the return line connects to the safety injection manifold which returns the fluid to the cold legs of all four loops. The residual heat exchangers are also used to cool the water circulated during the latter phase of safety injection system operation. The heat loads are transferred by the residual heat exchangers to the component cooling water.

During shutdown, the cooldown rate of the Reactor Coolant System is controlled by regulating the flow through the tube side of the residual heat exchangers. Two remotely-operated control valves downstream of the residual heat exchangers are used to control flow.

Double, remotely-operated valving is provided to isolate the Residual Heat Removal Loop from the Reactor Coolant System hot leg. When Reactor Coolant System pressure exceeds the design pressure of the Residual Heat Removal Loop, an interlock between the Reactor Coolant System wide range pressure channel and the first isolation valve prevents the valve from opening. A locked control is provided for the second isolation valve. A remotely-operated valves and two check valves isolate each line to the Reactor Coolant System Cold legs from the Residual Heat Removal Loop.

9.2.2.3 Spent Fuel Pit Cooling Loop

The Spent Fuel Pit Cooling Loop removes residual heat from fuel stored in the spent fuel pit. The loop is normally required to handle the heat load from 1/3 of the core freshly discharged from the reactor, but it can safely accommodate the heat load from 1-1/3 cores for which there is available storage space. The spent fuel is placed in the pit during refueling and is stored until it is shipped to a reprocessing facility.

The spent fuel pit cooling loop consists of a pump, a heat exchanger, filter, demineralizer, piping and associated valves and instrumentation. The pump draws water from the pit, circulates it through the heat exchanger and returns it to the pit. A second pump is used to circulate refueling water during purification. Component cooling water cools the heat exchanger. Redundancy of this equipment is not required because of the large heat capacity of the pit and the slow heat up rate. However, in the event of failure of the spent fuel pump alternate connections are provided for connecting a temporary pump to the spent fuel pit loop.

The clarity and purity of the spent fuel pit water is maintained by passing approximately 5 per cent of the loop flow through a filter and demineralizer. The spent fuel pit pump suction line which is used to drain the pit penetrates the spent fuel pit wall above the fuel assemblies stored in the pit to prevent loss of water as a result of a suction line rupture.

### 9.2.2.4 Component Cooling Loop Components

a) Component Cooling Heat Exchangers
The component cooling heat exchangers are of the shell and straight tube type. Service water circulates through the tubes while component cooling water circulates through the shell side. The shell is carbon steel and the tubes are of Admiralty metal.

b) Component Cooling Pumps
The component cooling pumps which circulate component cooling water through the component cooling loop are horizontal, centrifugal units of standard commercial construction.

c) Component Cooling Surge Tank
The component cooling surge tank which accommodates changes in component cooling water volume is constructed of carbon steel. In addition to piping connections, the tank has a flanged opening at the top for the addition of the chemical corrosion inhibitor to the component cooling loop.

d) Valves

The valves used in the component cooling loop are standard commercial valves constructed of carbon steel with bronze or stainless steel trim. Since the component cooling water is not normally radioactive, special features to prevent leakage to the atmosphere are not provided. Self-actuated, spring loaded relief valves are provided for lines and components that could be pressurized to their design pressure by improper operation or malfunction.

e) Piping

All component cooling loop piping is carbon steel with welded joints and connections except at components which might need to be removed for maintenance.

9.2.2.5 <u>Residual Heat Removal Loop Components</u>

a) Residual Heat Exchangers

The residual heat exchangers are of the shell and U-tube type with the tubes welded to the sheet. Reactor coolant circulates through the tubes, while component cooling water circulates through the shell side. The tube and other surfaces in contact with reactor coolant are austenitic stainless steel and the shell is carbon steel.

b) Residual Heat Removal Pumps

The residual heat removal pumps are horizontal, centrifugal units with special seals to prevent reactor coolant leakage to the atmosphere.

All pump parts in contact with reactor coolant are austenitic stainless steel or equivalent corrosion resistant material.

c) Residual Heat Removal Loop Valves

The valves used in the Residual Heat Removal Loop are constructed of austenitic stainless steel or equivalent corrosion resistant material.

Manual stop valves are provided to isolate equipment for maintenance. Throttle valves are provided for remote and manual control of residual heat exchanger tube side flow. The Residual Heat Removal Loop is isolated from the cold legs of the Reactor Coolant System by stop valves and check valves.

Remotely operated stop valves, one with a pressure interlock and the other with a locked control isolate the residual heat removal loop from the hot leg connection to the Reactor Coolant System.

Overpressure in the residual heat removal loop is relieved through a check valve to the low pressure letdown stream in the Chemical and Volume Control System.

Valves that perform a modulating function are equipped with two sets of packing and an intermediate leakoff connection that discharges to the Waste Disposal System. All other valves have stem leakage control features such as backseats. Leakoff connections are provided where required by valve size and fluid conditions.

d) Residual Heat Removal Piping
All residual heat removal loop piping is austenitic stainless steel. The piping is welded with flanged connections at the pumps.

9.2.2.6 Spent Fuel Pit Loop Components

a) Spent Fuel Pit Heat Exchanger
The spent fuel pit heat exchanger is of the shell and U-tube type with the tubes welded to the tube sheets. Component cooling water circulates through the shell, and spent fuel pit water circulates through the tubes. The tubes and other surfaces in contact with the spent fuel pit water are austenitic stainless steel and the shell is carbon steel.

b) Spent Fuel Pit Pump

The spent fuel pit pump circulates water in the spent fuel pit cooling loop. All wetted surfaces of the pump are austenitic stainless steel, or equivalent corrosion resistant material. The pump is operated manually from a local station.

c) Spent Fuel Pit Filter

The spent fuel pit filter removes particulate matter larger than 5 microns from the spent fuel pit water. The filter cartridge is a synthetic fiber and the vessel shell is austenitic stainless steel.

d) Spent Fuel Pit Cooling Loop Valves

Manual stop valves are used to isolate equipment and lines and manual throttle valves provide flow control. Valves in contact with spent pit water are austenitic stainless steel or equivalent corrosion resistant material.

e) Spent Fuel Pit Cooling Loop Piping

All piping in contact with spent fuel pit water is austenitic stainless steel. The piping is welded except where flanged connections are used at the pump, heat exchanger, and filter to facilitate maintenance.

f) Spent Fuel Pit Demineralizer

A flushable, mixed bed demineralizer utilizing a hydrogen form cation resin and hydroxyl form anion resin maintains spent fuel pit water purity.

g) Refueling Water Purification Pump

The refueling water purification pumps circulates water in a loop between the refueling water storage tank and the spent fuel pit demineralizer.. All wetted surfaces of the pump are austenitic stainless steel. The pump is operated manually from a local station.

## 9.3 SAMPLING SYSTEM

### 9.3.1 DESIGN BASIS

The Sampling System provides a means to obtain liquid and gaseous fluid samples for laboratory analysis of reactor coolant chemistry and radiochemistry.

### 9.3.2 SYSTEM DESIGN AND OPERATION

The Sampling System, shown in Figure 9-5, is designed to provide representative samples for laboratory analysis used to guide the operation of the Reactor Coolant System, Auxiliary Coolant System and the Chemical and Volume Control System. These samples are used to determine both chemical and radiochemical conditions. Typical of the analyses performed on such samples are reactor coolant boron concentrations, fission product radioactivity level, dissolved gas content, and corrosion product concentration.

Analytical results are used in regulating boron concentration adjustment, evaluating fuel element integrity, evaluating mixed bed demineralizer performance, and in regulating additions of corrosion controlling chemicals to the systems. The Sampling System is designed to be operated manually, on an intermittent basis for conditions ranging from full power operation to cold shutdown.

Reactor coolant liquid and steam sampling lines which are normally inaccessible or which require frequent sampling are sampled by means of permanently installed tubing leading to a central sampling room. Each of these sample lines inside the reactor containment has a remotely operated isolation valve close to the source of the sample. A delay coil is provided for decay of short-lived radioactive isotopes present in the reactor coolant system liquid sample. The samples are cooled as they flow through the sample heat exchangers and the pressure is reduced by pressure reducing valves. The reactor coolant then flows to the volume control tank or the waste disposal system through a purge line until sufficient purge volume has passed to permit collection of a representative sample in the sample vessels, or at the sample sink.

Liquid samples originating upstream and downstream of the Chemical and Volume Control System mixed bed demineralizer pass through the low pressure sample header to the sample sink.

Gaseous samples from the volume control tank of the Chemical and Volume Control System are collected in a sample vessel. The vessel is purged to the vent header of the Waste Disposal System. Local samples are collected in a sample vessel or other suitable container for transfer to the laboratory.

Because the pressurizer steam phase sample, the reactor coolant dissolved gas sample and volume control tank gas phase sample may contain accumulated radioactive gases, the respective sample vessel stations are located in small, well ventilated and shielded cubicles within the sampling room.

If remote handling of the sample vessels becomes necessary, extension handles can be used to operate the isolation valves and the quick-disconnect couplings.

The sample sink, which is contained in the laboratory bench as a part of the sampling hood, contains a drain line to the Waste Disposal System and is provided with a supply of demineralized water for flushing and clean up purposes.

## 9.3.3 COMPONENTS

a) Sample Heat Exchangers

The sample heat exchanger reduces the sample temperature before it reaches the sample vessels. These units consists of coiled sections of tubing inside jackets. The reactor coolant sample stream flows through the coils and component cooling water from the Auxiliary Coolant System circulates through the jackets. All parts of the heat exchangers contacting the reactor coolant are austenitic stainless steel. The inlet and outlet ends have socket-weld joints for connection to the high pressure sample lines. Three heat exchangers are provided, one for pressurizer steam samples, one for pressurizer liquid samples and the other for reactor coolant system liquid samples.

b) Delay Coil

The high pressure reactor coolant sample line contains a delay coil consisting of tubing which has sufficient length to provide the required sample transit time to allow for decay of short lived isotopes.

c) High Pressure Sample Vessels

Each high pressure sample train contains a sample pressure vessel which is used to obtain dissolved gas samples. Integral isolation valves are furnished with the vessel and quick-disconnect coupling valves (containing poppet-type check valves) are connected to nipples extending from the valves on each end. The vessel, valves and couplings are austenitic stainless steel.

d) Sample Sink

The sample sink is located in a hooded enclosure which is equipped with an exhaust ventilator. The work area around the sink and the enclosure is large enough to provide space for radiation monitoring equipment in addition to the space needed for sample collection and storage. The sink perimeter has a raised edge to contain any spilled liquid.

In addition to the incoming sample lines, which may include lines from the secondary system, the enclosure is penetrated by a demineralized water line, which discharges into the sink. The sink and work area are stainless steel.

e) Volume Control Tank Sample Vessel

The volume control tank sample vessel is used to collect gas samples from the volume control tank in the Chemical and Volume Control System or from the pressurizer relief tank to determine the composition of the gases (primarily hydrogen and any fission gases) in the tanks.

f) Piping and Fittings

All liquid and gas sample lines are austenitic stainless steel tubing and are designed for high pressure service. With the exception of the sample vessel quick-disconnect couplings, socket welded joints are used throughout the Sampling System. Lines are located so as to be protected from accident damage during routine operation and maintenance.

g) Valves

Remotely operated stop valves are used to isolate all sample points and to route sample fluid flow inside the reactor containment. Manual stop valves are provided for component isolation and flow path control at all normally accessible Sampling System locations. Manual throttle valves are provided to adjust the sample flow rate. Check valves prevent reverse flow from the volume control tank into the sample sink. All valves in the system are constructed of austenitic stainless steel or equivalent corrosion resistant material.

## 9.4 FUEL HANDLING SYSTEM

### 9.4.1 DESIGN BASIS

The Fuel Handling Systems are designed to provide a safe, effective means of transporting and handling fuel from the time it reaches the plant in an unirradiated condition until it leaves the plant after post-irradiation cooling. The system is designed to minimize the possibility of mishandling or maloperations that would cause fuel damage and potential fission product release.

### 9.4.2 SYSTEM DESIGN AND OPERATION

The reactor is refueled with equipment designed to handle the spent fuel under water from the time it leaves the reactor vessel until it is placed in a cask for shipment from the site. Underwater transfer of spent fuel provides an effective, economic and transparent radiation shield, as well as a reliable cooling medium for removal of decay heat. Boric acid is added to the water to further ensure subcritical conditions during refueling.

The Fuel Handling System may be generally divided into two areas; the reactor cavity which is flooded only during plant shutdown for refueling and the spent fuel pit which is kept full of water and is always accessible to operating personnel. These two areas are connected by the Fuel Transfer System consisting of an underwater conveyor that carries the fuel through an opening in the plant containment.

In the reactor cavity fuel is removed from the reactor vessel, transferred through the water and placed in the fuel transfer system by a manipulator crane. In the spent fuel pit the fuel is removed from the transfer system and placed in storage racks with long manual tools suspended from an overhead crane. After a sufficient decay period, the fuel is removed from storage and loaded into a shipping cask for removal from the site.

New fuel assemblies are stored in racks in the new fuel storage area. New fuel is transferred to the reactor by lowering it into the spent fuel pit and taking it through the transfer system. Alternately, the new fuel may be taken through the reactor containment equipment hatch and lowered directly into the reactor cavity. The new fuel storage area is sized for storage of the fuel assemblies and control rods normally associated with the replacement of one-third of a core. The fuel for the initial core loading will be temporarily stored in the spent fuel storage pit. The pit will be kept dry during this period.

### 9.4.3 FUEL HANDLING STRUCTURES

#### 9.4.3.1 Reactor Cavity

The reactor cavity is a reinforced concrete structure that forms a pool above the reactor when it is filled with borated water for refueling. The cavity is filled to a depth that limits the radiation at the surface of the water to 50 milliroentgens per hour during those brief periods when a fuel assembly is transferred over the reactor vessel flange and is at the closest approach to the surface of the water.

The reactor vessel flange is sealed to the bottom of the reactor cavity by a bolted, gasketed seal ring which prevents leakage of refueling water from the cavity. This seal is fastened and closed prior to flooding the cavity for refueling operations.

The cavity is large enough to provide storage space for the reactor upper internals, the control cluster drive shafts, and miscellaneous refueling tools. Space is also allowed for the storage of the lower internals if required.

The floor and sides of the reactor cavity are lined with stainless steel.

### 9.4.3.2 Fuel Transfer Canal

The fuel transfer canal is a passageway extending from the reactor cavity to the inside surface of the reactor containment. The canal is formed by two concrete shielding walls, which extend upward to the same elevation as the reactor cavity. The floor of the canal is at a lower elevation than the reactor cavity to provide the greater depth required for the fuel transfer system tipping device and the control cluster changing fixture located in the canal. The transfer tube enters the reactor containment and protrudes through the end of the canal. Canal wall and floor linings are stainless steel similar to the reactor cavity.

### 9.4.3.3 Spent Fuel Storage Pit

The spent fuel storage pit is designed for the underwater storage of spent fuel assemblies and control rods after their removal from the reactor. It is designed to accommodate a total of approximately one and one-third core and a shipping cask.

Spent fuel assemblies are handled by a long handled tool suspended from an overhead monorail electric hoist and manipulated by an operator standing on a movable bridge over the pit. The spent fuel storage pit is constructed of reinforced concrete. The entire interior basin face and transfer canal are lined with stainless steel plate.

A storage rack erected on the pit floor is provided to hold spent fuel assemblies. Fuel assemblies will be placed in vertical cells, continuously grouped in parallel rows $\sim$21 in. on centers in both directions. The racks are designed so that it is impossible to insert fuel assemblies in other than the prescribed locations, thereby ensuring the necessary spacing between assemblies to prevent criticality even if the pit were filled with unborated water. Control rod clusters are stored in the fuel element assemblies.

### 9.4.3.4 New Fuel Storage and Decontamination Facilities

New fuel assemblies and control rods are stored in an area designed to hold approximately 1/3 of a core of new fuel assemblies. The assemblies which make up the remaining two-thirds of a first core will be stored in the spent fuel pit. The new fuel assemblies are stored in racks in parallel rows having a center-to-center distance of 21 inches.

Decontamination facilities, consisting of an equipment and cask pit, are located adjacent to the spent fuel storage pit. Cask handling and other tools can be cleaned and decontaminated in the cask decontamination pit. The outside surfaces of the casks are decontaminated, if required, by using steam, water, detergent solutions, and manual scrubbing to the extent required.

## 9.4.4 FUEL HANDLING EQUIPMENT

### 9.4.4.1 Reactor Vessel Stud Tensioner

Stud tensioners are used to make up the head closure joint and during this process all studs are stretch tested to more than nominal working loads at every refueling.

The stud tensioner is a hydraulically operated (oil as the working fluid) device provided to permit preloading and unloading of the reactor vessel closure studs at cold shutdown conditions. Stud tensioners were chosen in order to minimize the time required for the tensioning or unloading operations. Three tensioners are provided and they are applied simultaneously to three studs 120° apart. One hydraulic pumping unit operates the tensioners which are hydraulically connected in series. The studs are tensioned to their operational load in two steps to prevent high stresses in the flange region and unequal loadings in the studs. Relief valves are provided on each tensioner to prevent overtensioning of the studs due to excessive pressure.

Charts indicating the stud elongation and load for a given oil pressure are included in the tensioner operating instructions. In addition, micrometers are provided to measure the elongation of the studs after tensioning.

### 9.4.4.2 Reactor Vessel Head Lifting Device

The reactor vessel head lifting device consists of a welded and bolted structural steel frame with suitable rigging to enable the crane operator to lift the head and store it during refueling operations. The lifting device is permanently attached to the reactor vessel head and includes means for directing cooling air to the control cluster drive mechanisms.

### 9.4.4.3 Reactor Internals Lifting Device

The reactor internals lifting device is a structural frame suspended from the overhead crane on a long sling. The frame is lowered onto the guide tube support plate of the internals and air operated latching pins are remotely actuated to engage lifting lugs on the support plate. Bushings on the frame engage guide studs in the vessel flange to provide close guidance during removal and replacement of the internals package.

### 9.4.4.4 Manipulator Crane

The manipulator crane is a motor driven rectilinear bridge and trolley crane with a vertical mast extending down into the refueling water. The bridge spans the reactor and refueling cavity and runs on rails set into the floor along the edge of the cavity. The bridge and trolley motions are used to position the vertical mast over a fuel assembly in the core. A long tube with a pneumatic gripper on the end is lowered down through the mast to grip the fuel assembly. The gripper tube is long enough so the upper end is still contained in the mast when the gripper end contacts the fuel. A winch mounted on the trolley raises the gripper tube and fuel assembly up into the mast tube. The fuel is transported while inside the mast tube to its new position.

#### 9.4.4.5 Spent Fuel Pit Bridge

The spent fuel pit bridge is a wheel-mounted motor driven walkway spanning the spent fuel pit. An overhead beam over one side of the walkway supports a monorail electric hoist for use with long handled tools. The hoist travel, tool, and sling length are designed to limit the maximum lift of a fuel assembly to a safe shielding depth.

#### 9.4.4.6 Fuel Transfer System

The fuel transfer system, shown in Figure 9-6, is an underwater cable, motor driven conveyor car that runs on tracks extending from the refueling canal through the transfer tube and into the spent fuel pit. The conveyor car receives a fuel assembly in the vertical position from the manipulator crane. The fuel assembly is lowered to a horizontal position for passage through the tube, and then it is raised to a vertical position in the spent fuel pit.

During plant operation, the conveyor car is stored in the refueling canal. A gate valve in the transfer tube is closed to permit placement of the seal flange at the end of the refueling canal tube.

#### 9.4.4.7 Rod Cluster Control Changing Fixture

A fixture is mounted on the reactor cavity wall for removing rod cluster control (RCC) elements from spent fuel assemblies and inserting them into new fuel assemblies. The fixture consists of two main components; a guide tube mounted to the wall for containing and guiding the RCC element, and a wheel-mounted carriage for holding the fuel assemblies and positioning fuel assemblies under the guide tube. The guide tube also contains a pneumatic gripper on a winch that grips the RCC element and lifts it out of the fuel assembly. By repositioning the carriage, a new fuel assembly is brought under the guide tube and the gripper lowers the RCC element and releases it. The manipulator crane loads and removes the fuel assemblies into and out of the carriage.

## 9.4.5 REFUELING OPERATION

The refueling operation will follow a detailed procedure which will be established to provide a safe, efficient refueling operation. The following significant points will be ensured by the refueling procedure:

1) The refueling water and the reactor coolant will contain $\sim$2100 ppm boron. The concentration together with the control rods is sufficient to keep the core approximately 10% subcritical during the refueling operations. It is also sufficient to maintain the core shutdown if all of the RCC assemblies were removed from the core.

2) The water level in the refueling canal will be high enough to keep the radiation levels within acceptable limits when the fuel assemblies are being removed from the core. This water also provides adequate cooling for the fuel assemblies during transfer operations.

3) Fuel handling operations and equipment will be designed so that the possibility of fuel mishandling or damage is minimized.

## 9.4.6 HANDLING OF FAILED FUEL ASSEMBLIES

The suspected defective fuel assembly is placed in a failed fuel can and sealed to provide an isolated chamber for testing for the presence of fission products.

The failed fuel cans are stainless steel cylinders with lids that can be bolted in place remotely. An internal gas space in the lid provides for water expansion and for collection and sampling of fission product gases. Various remotely operable quick-disconnect fittings permit connection of the can to sampling loops for continuous circulation through the can.

If sampling shows the presence of fission products indicative of a cladding failure, the sampling lines are closed off by valves on the can and the encapsulated fuel assembly is removed to the spent fuel storage racks to await shipment. Design of the cans complies with federal regulation 10 CFR 72 so that the defective fuel can be stored and shipped while sealed in the failed fuel can.

## 9.5 SERVICE WATER SYSTEM

River water is used for service water purposes for the nuclear and conventional plants.

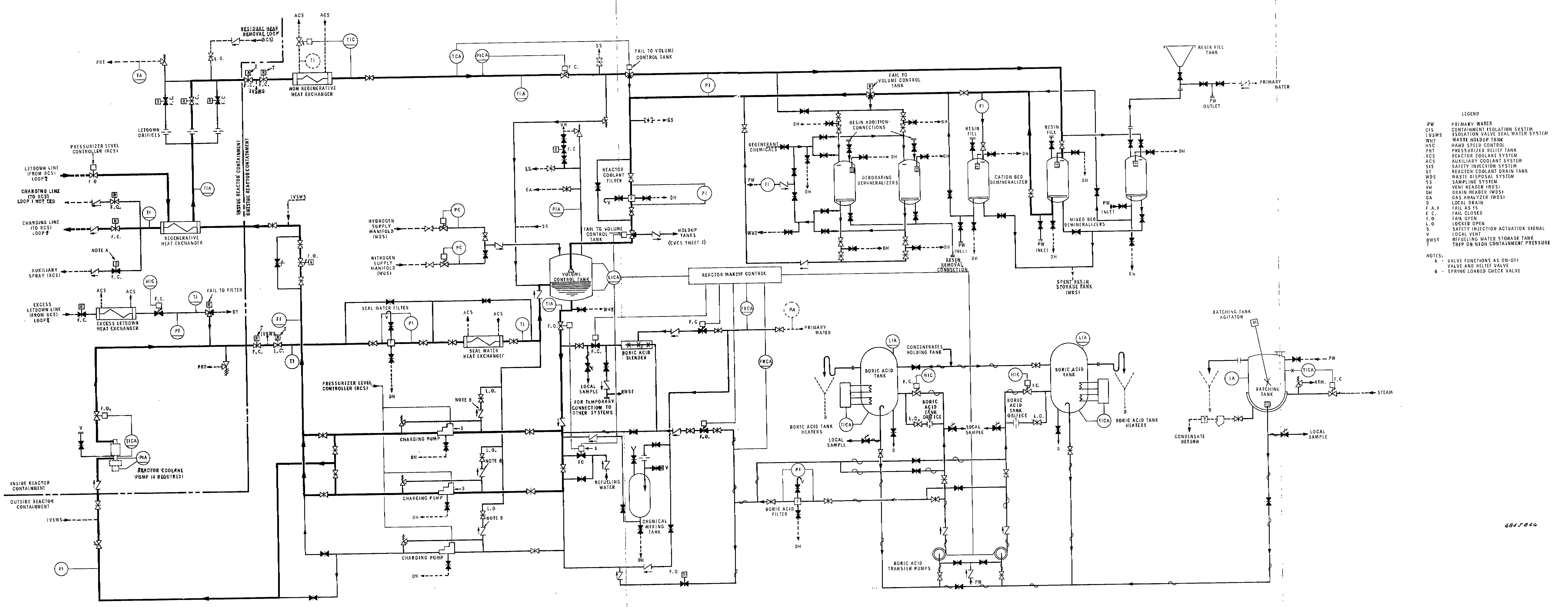
Figure 9-7 is a flow diagram showing the service water system. There are six identical service water pumps which supply water to two independent pump discharge headers, each header being supplied by three service water pumps. Each header supplies an independent supply line. Either of the two supply lines can be designated to supply the ventilation fan coolers and essential secondary loads, with the other supply line feeding the conventional turbine loads, and the component cooling loads. By manual valve operation the designated functions of the supply lines can be interchanged.

The cooling water requirements for all five fan cooling units and the other essential loads can be supplied by any two of the three service water pumps on the header designated to supply the nuclear and essential secondary load supply lines. Any two of the three pumps can be powered by the emergency diesels. These emergency powered pumps are those necessary and sufficient to meet blackout and emergency conditions. Either set of these pumps can be placed on the diesel starting logic.

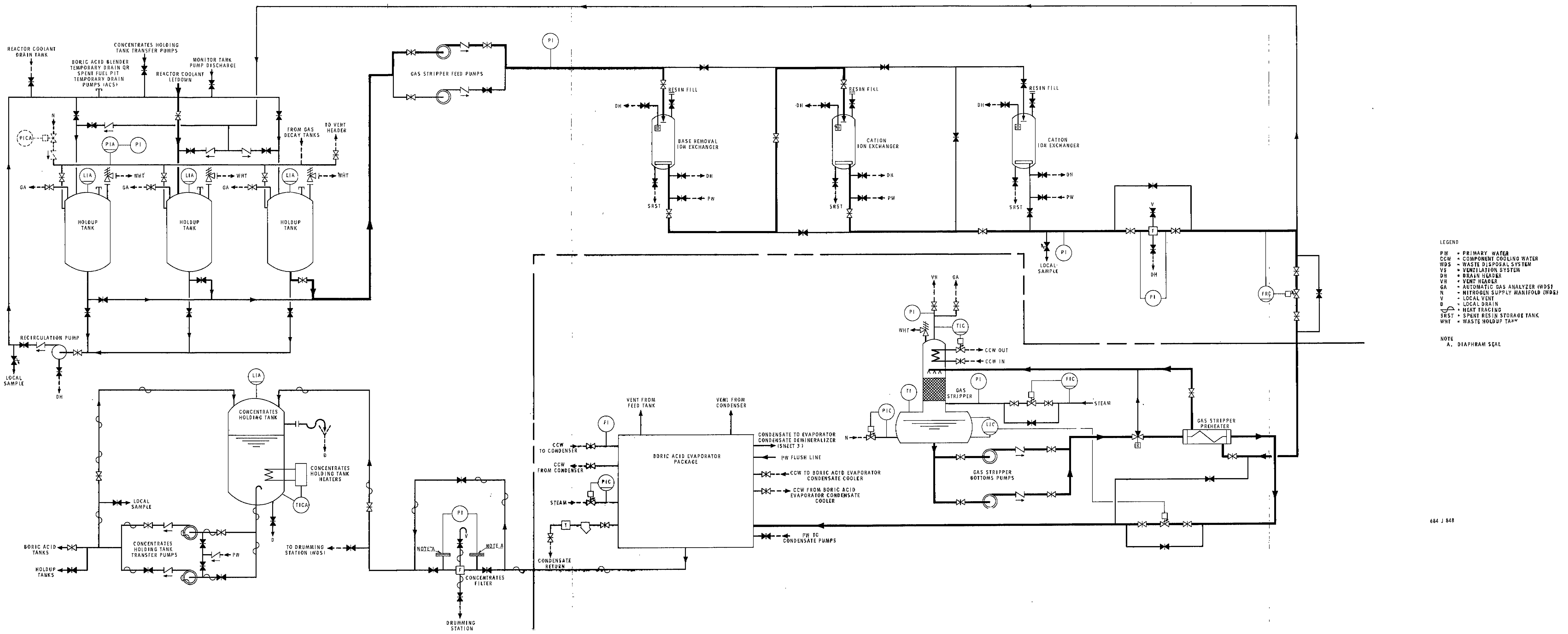
The containment ventilation cooling units are supplied by individual lines from the containment service water header. Each inlet line is provided with a manual shutoff valve and drain valve. Similarly, each discharge line from the cooler is provided with a manual shutoff valve. This allows each cooler to be isolated individually for leak testing of the system or to be drained and maintained open to the atmosphere during the integrated leak tests of the containment.

The ventilation cooler discharge lines will be monitored for radioactivity by routing a small bypass flow from each through redundant radiation monitors. Upon indication of radioactivity in the effluent, each cooler discharge line would be monitored individually to locate the defective cooling coil. However, since the cooling coils and service water lines are completely closed inside the containment, no contaminated leakage is expected into these units. The service water system pressure at locations inside the containment is below the containment design pressure of 47 psig.

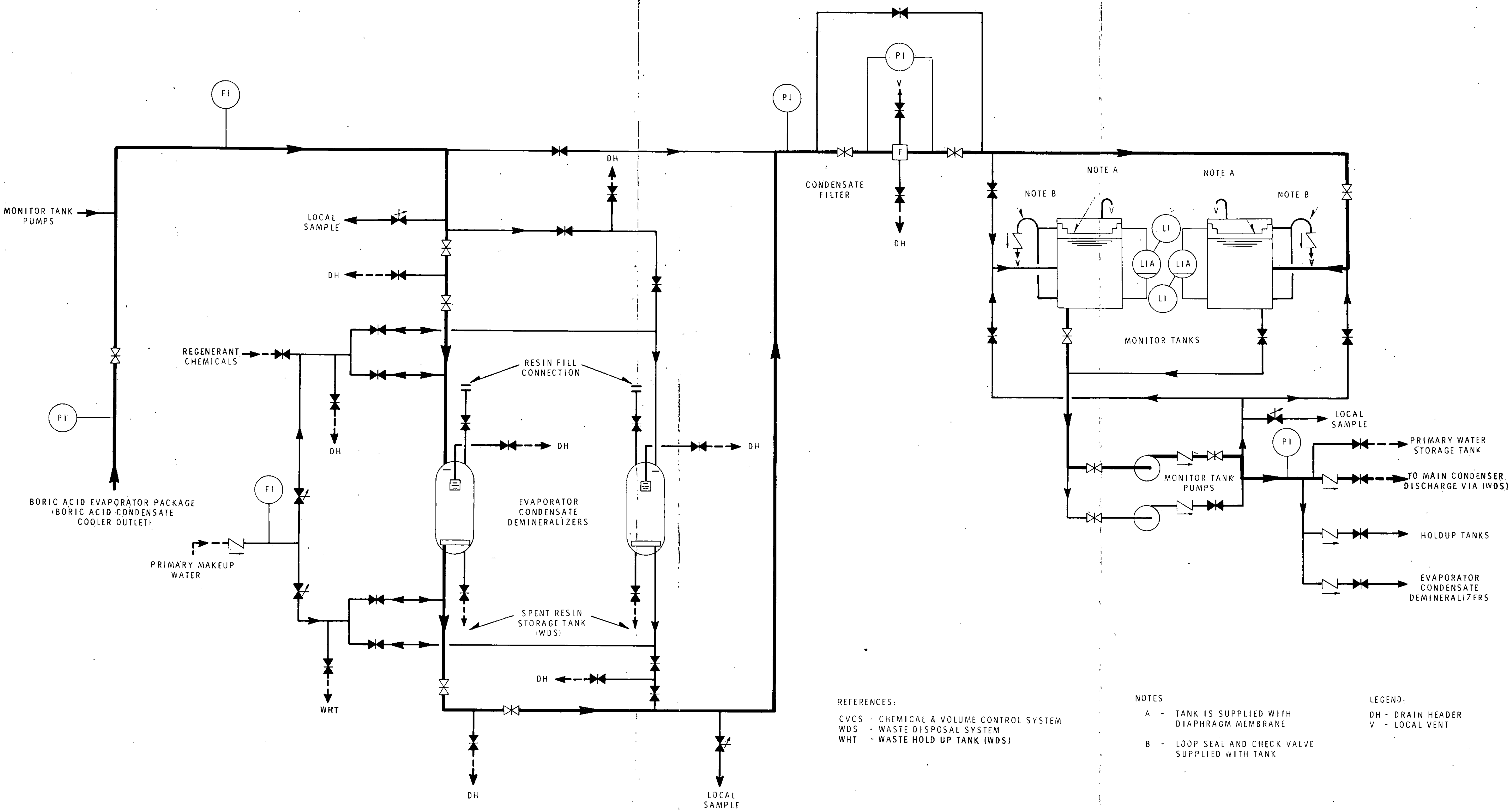
During normal plant operation, flow through the cooling units will be throttled for containment temperature control purposes by a valve on the common discharge header from the cooling units. Two independent, full flow, isolation valves open automatically in the event of a high containment pressure signal to bypass the control valve. Both valves fail in the open position upon loss of air pressure and either valve is capable of passing the full flow required for all five fan cooling units.



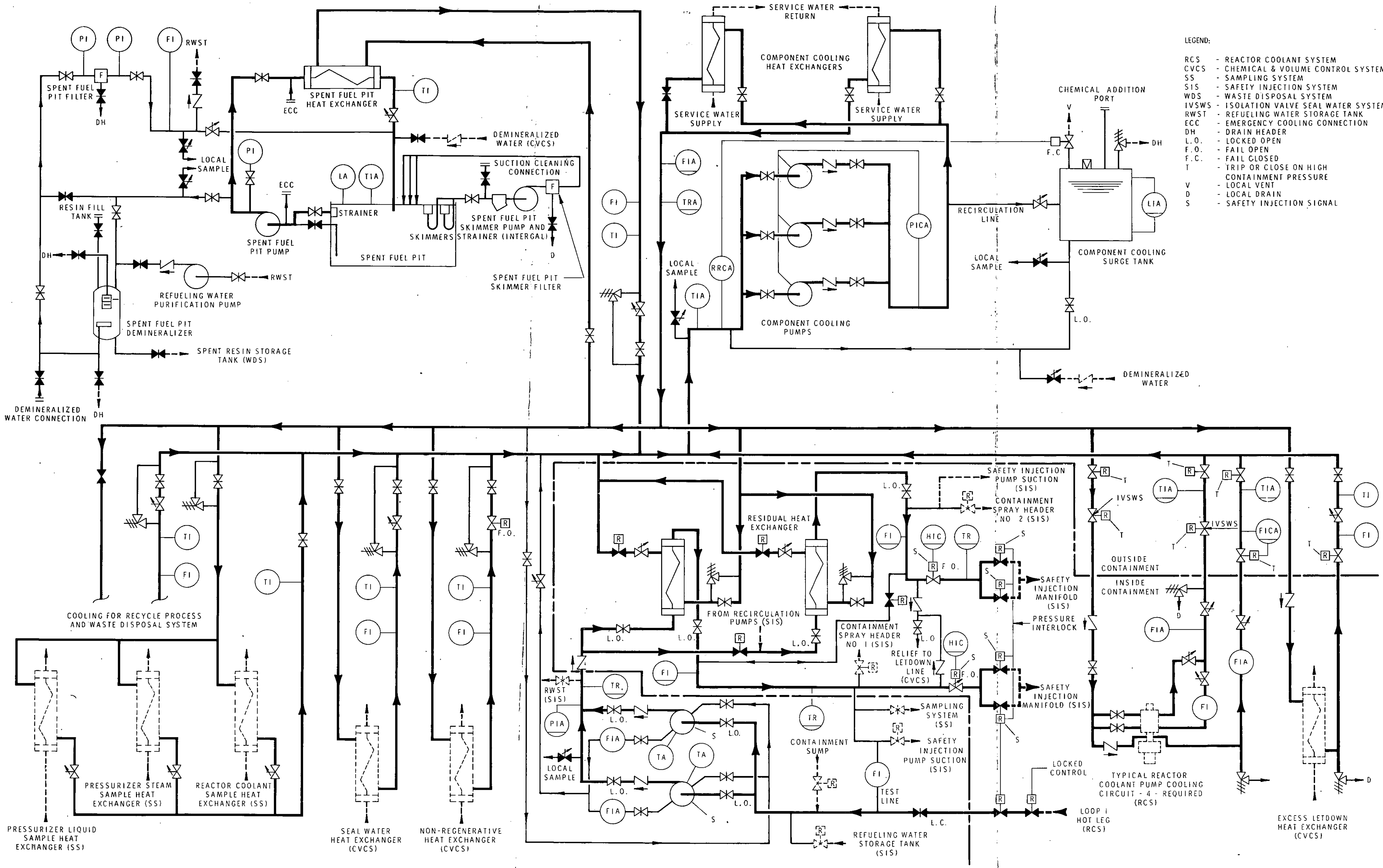

CHEMICAL AND VOLUME CONTROL SYSTEM (Sht. 1)
FIG. 9-1




CHEMICAL AND VOLUME CONTROL SYSTEM (Sht. 2)
FIG. 9-2



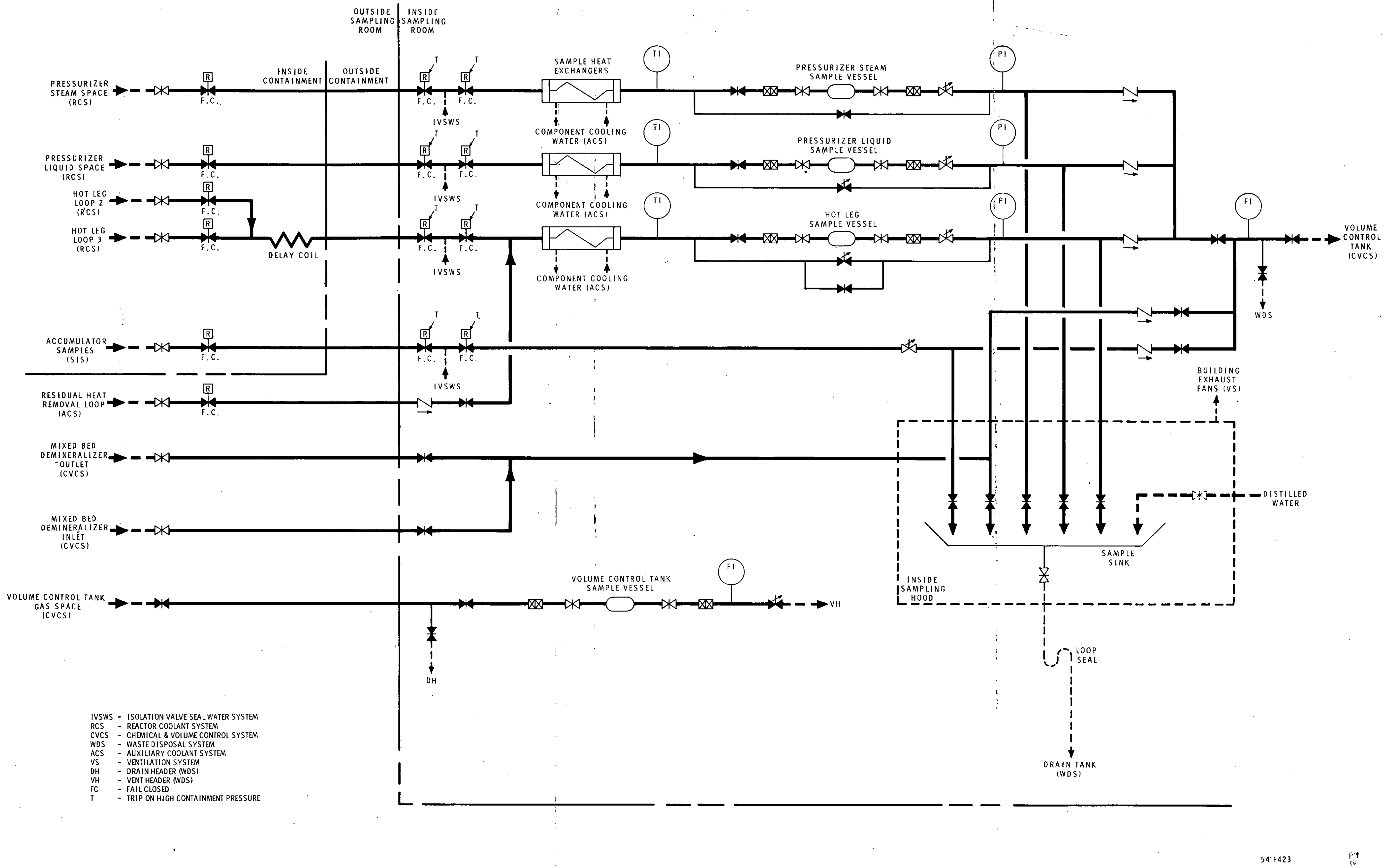

CHEMICAL AND VOLUME CONTROL SYSTEM (Sht. 3)
FIG. 9-3



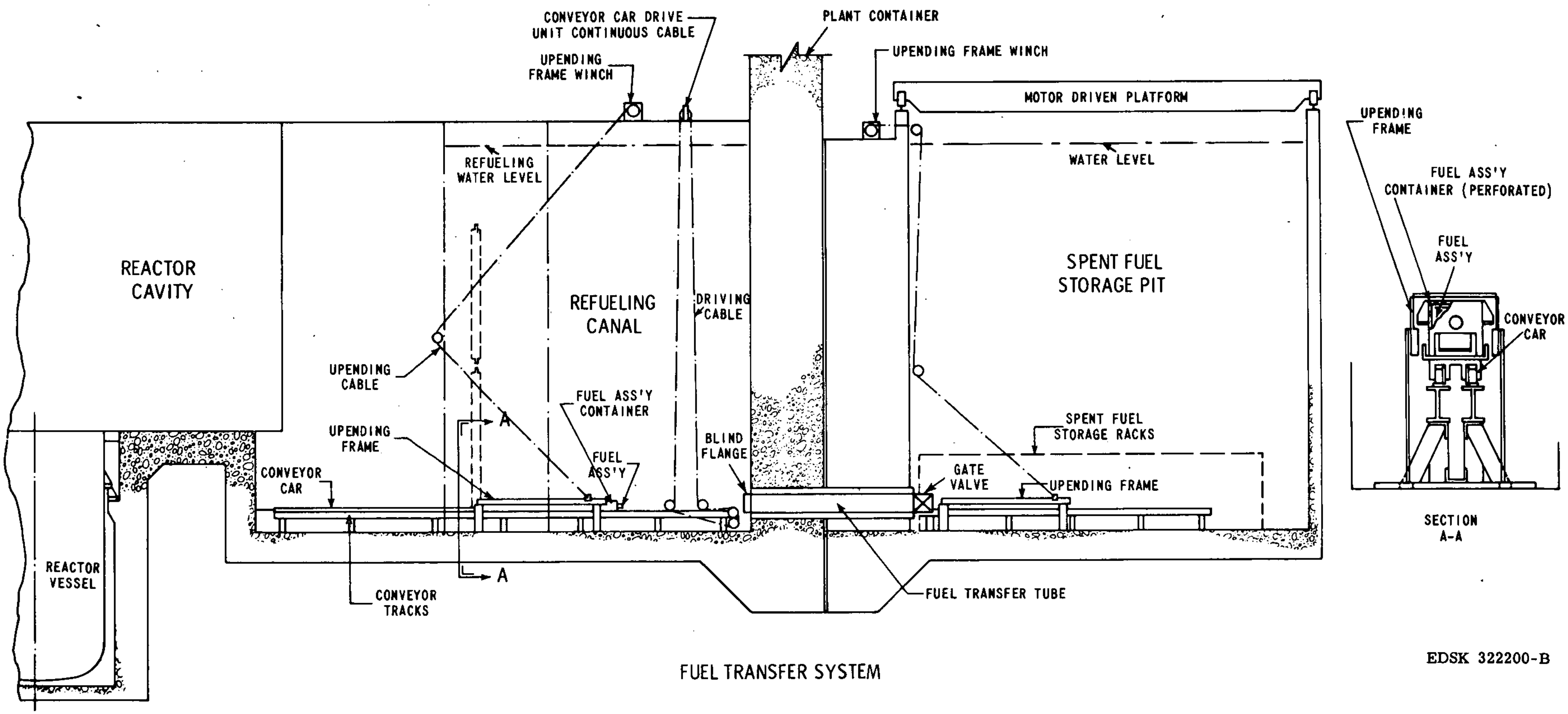

LEGEND:

RCS - REACTOR COOLANT SYSTEM
CVCS - CHEMICAL & VOLUME CONTROL SYSTEM
SS - SAMPLING SYSTEM
SIS - SAFETY INJECTION SYSTEM
WDS - WASTE DISPOSAL SYSTEM
IVSWS - ISOLATION VALVE SEAL WATER SYSTEM
RWST - REFUELING WATER STORAGE TANK
ECC - EMERGENCY COOLING CONNECTION
DH - DRAIN HEADER
L.O. - LOCKED OPEN
F.O. - FAIL OPEN
F.C. - FAIL CLOSED
T - TRIP OR CLOSE ON HIGH CONTAINMENT PRESSURE
V - LOCAL VENT
D - LOCAL DRAIN
S - SAFETY INJECTION SIGNAL

AUXILIARY COOLANT SYSTEM
FIG. 9-4



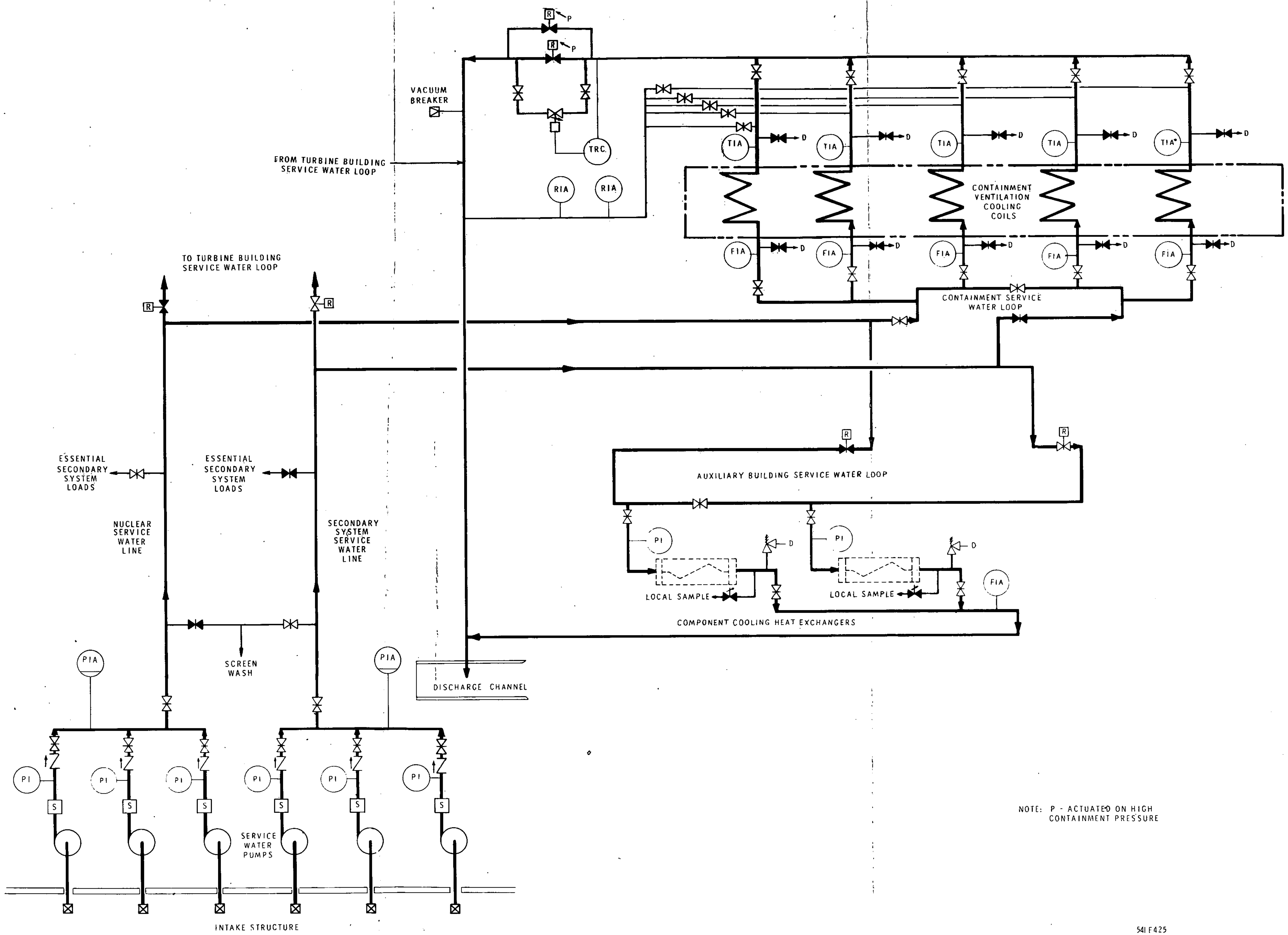

SAMPLING SYSTEM
FIG. 9-5




FUEL TRANSFER SYSTEM

EDSK 322200-B

FUEL TRANSFER SYSTEM
FIG. 9-6




SERVICE WATER SYSTEM
FIG. 9-7

SECTION 10

| PSAR Section | Page | Remarks |
|---|---|---|
| 10.2.2 | 10-2 | A description of the main steam line valves and revised Figure 10-1 (Steam and Feedwater System flow diagram) is given in Item 16 (E - 3.4) of Supplement 1. |
| 10.2.3 | 10-3 | A description of the condensate and feedwater system under accident conditions is presented in Item 2 (1 - 13) of Supplement 1. |
| 10.2.3 | 10-3 | A description (including a figure) of the steam supply to the auxiliary feedwater pump is given in Item 17 (F - 7.0) of Supplement 1. |