9.0 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, and maintains the proper concentration of corrosion inhibiting chemicals in the reactor coolant. The system is also used to fill and hydrostatically test the Reactor Coolant System.

System integrity is assured by conformance to applicable codes listed in Table 9-1 and by the 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	ASME III, Class C
Seal water filter	ASME III, Class C
Excess letdown heat exchanger	ASME III, Class C
Boric acid filter	ASME III, Class C
Chemical addition tank	ASME VIII
Piping and valves	ASA-B31.1**, Section 1

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*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

A flow diagram of the Chemical and Volume Control System is shown in Figure 9-1.

During plant operation, reactor coolant flows from a cold leg of the Reactor Coolant System and is returned to a cold leg via a charging line. Each of the connections to the Reactor Coolant System has an isolation valve located close to the loop piping. In addition, a check valve is located downstream of the 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 enters the residual heat removal loop of the Auxiliary Coolant System where the temperature is further reduced in the tube side of one of the residual heat exchangers. On leaving the residual heat removal loop, 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 the 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 four 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 returns to the volume control tank through the excess letdown and seal water heat exchangers.

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

a) The demineralized water supply, which provides 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.

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 austenitic stainless steel with the shell and heads of welded construction.

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 Residual Heat Exchangers

During normal power operation, one of two residual heat exchangers is used by the Chemical and Volume Control System to cool the letdown stream to the operating temperature of the mixed bed demineralizer. These heat exchangers are part of the Auxiliary Coolant System.

9.1.3.4 Mixed Bed Demineralizers

Two flushable, mixed bed demineralizers maintain reactor coolant water purity. A lithium 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 Spent Fuel Pit Demineralizer

A flushable, mixed bed demineralizer utilizing a hydrogen form cation resin and a hydroxyl form anion resin maintains spent fuel pit water purity. The spent fuel pit and mixed bed demineralizers have the same resin volume.

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 mixed bed and spent fuel pit demineralizers.

9.1.3.7 Reactor Coolant Filter

The filter collects resin fines and particulate matter larger than 25 microns. This filter uses replaceable synthetic fiber cartridges. The vessel is 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

Two charging pumps inject coolant into the Reactor Coolant System and reactor coolant pump shaft seals. Normally, one pump is operating while the other serves as a standby. The pumps are positive displacement types 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.

The pumps are normally energized manually from the central control room, but are also started automatically in the event of low pressurizer level.

9.1.3.10 Seal Water Heat Exchanger

The seal water heat exchanger cools the reactor coolant pump 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 Metering Pump

A small, positive displacement pump is provided to transfer solutions from the chemical addition tank and to pressure test the Reactor Coolant System. The pump can also be used for emergency boration of the coolant and for emergency labyrinth seal flow if the charging pumps become inoperative. All metal surfaces in contact with reactor coolant are stainless steel or material of equivalent corrosion resistance. A stuffing box leakoff is piped to the Waste Disposal System to prevent leakage of reactor coolant.

9.1.3.12 Boric Acid Pumps

Two centrifugal canned motor pumps circulate boric acid solution through the batching tank, transfer the batch to the boric acid tanks and inject boric acid into the charging pump or metering pump suction header.

Although one pump is normally used for boric acid batching and transfer and the other for boric acid injection, either pump may function as standby for the other. All parts in contact with the solution are austenitic stainless steel.

9.1.3.13 Boric Acid Tanks

Boric acid solution recovered from the Waste Disposal System or mixed in the matching tank is stored in two 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 other 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 and corrected as required before use as reactor coolant makeup. The tanks are constructed of austenitic stainless steel.

9.1.3.14 Chemical Addition Tank

The chemical addition tank is used to inject chemical solution for use in the plant. Its chief use is the addition of caustic solutions for reactor coolant pH control and hydrazine for oxygen scavenging. Radioactive chemicals are never used in this tank. The chemical addition tank is austenitic stainless steel.

9.1.3.15 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.

9.1.3.16 Batching Tank

The batching tank is used to mix boric acid solution for the boric acid tank. 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.

9.1.3.17 Electric Heaters

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

9.1.3.18 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. Globe valves are installed with flow over the seats when such an arrangement reduces the possibility of leakage. Basic material of construction is stainless steel for all valves except the batching tank steam jacket valves which are carbon steel.

Stop valves are provided to isolate all connections to the Reactor Coolant System. Lines entering the reactor containment also have check valves inside the containment 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 charging line isolation valve which is designed to open when pressure under the seat exceeds reactor coolant pressure by 250 psi.

9.1.3.19 Piping

All Chemical and Volume Control System piping is austenitic stainless steel except for the line to the batching tank steam jacket. 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 solution, are heated by electrical tracing to ensure solubility of the boric acid.

9.2 AUXILIARY COOLANT SYSTEM

9.2.1 DESIGN BASIS

The Auxiliary Coolant System removes residual and sensible heat from the Reactor Coolant System during plant shutdown, cools the spent fuel pit water, 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 III*, Class C
Component Cooling Surge Tank	ASME III*, Class C
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

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

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

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

a) The seal water heat exchanger.
b) The excess letdown heat exchanger.
c) The sample heat exchanger.
d) The residual heat exchangers.
e) The spent fuel pit heat exchanger.
f) The reactor coolant pumps.

The Auxiliary Coolant System as shown in Figure 9-2 consists of three loops: the Component Cooling Loop, the Residual Heat Removal Loop and the Spent Fuel Pit Cooling Loop.

9.2.2 SYSTEM DESIGN AND OPERATION

9.2.2.1 Component Cooling Loop

The component cooling loop removes heat from the residual, seal water, spent fuel pit, excess letdown and sample heat exchangers and the reactor coolant pumps. These units are in parallel flow circuits. Component cooling water flows through them, picks up heat from the reactor coolant, and flows to heat exchangers which are cooled by river water. The component cooling loop thus serves as an intermediate system between the reactor coolant and river cooling water. This double barrier arrangement reduces the probability of leakage of high pressure, potentially radioactive coolant to the river cooling water supply.

During normal full power operation, one of the three component cooling pumps and one of two component cooling heat exchangers accommodate the heat removal loads. A standby pump and heat exchanger provide 100 per cent backup during normal operation. All three pumps and both 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 of the plant is not affected; only the time for shutdown is extended.

Component cooling water is circulated through the jacket side of the sample heat exchanger, and the shell side of the residual heat exchanger, the seal water heat exchanger and the excess letdown heat exchanger. 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 exchangers are also used for removing heat from the reactor coolant letdown flow during operation of the Chemical and Volume Control System.

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 cold leg of another loop. The residual heat exchangers are used to cool the coolant letdown stream during operation of the Chemical and Volume Control System and are also used to cool the water circulated during the latter phase of Safety Injection System operation. These duties are defined in the sections describing

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these systems. The heat loads are transferred by the residual heat exchangers to the component cooling water.

During plant shutdown, the cooldown rate of the reactor coolant is controlled by regulating the flow through the tube side of the residual heat exchangers. A bypass line and control valve around the residual heat exchangers are used to maintain a constant flow through the residual heat removal loop. When the residual heat exchangers are used for cooling the reactor coolant letdown flow, temperature control is accomplished by regulating the flow rate of the component cooling water.

Double, remotely-operated valving is provided to isolate the residual heat removal loop from the Reactor Coolant System. 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 set of valves prevents the valves from opening.

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. 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 is located outside the reactor containment and is not affected by any loss-of-coolant accident in the containment. The water in the pit is separated from that in the refueling canal by a valve during refueling, with only a very small amount of interchange of water as fuel assemblies are transferred.

The spent fuel pit cooling loop consists of a pump, 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. 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.

The clarity and purity of the spent fuel pit water is maintained by passing approximately 10 per cent of the loop flow through a filter and demineralizer. This demineralizer is included as part of the Chemical and Volume Control System. 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.

9.2.2.3 Component Cooling Loop Components

a) Component Cooling Heat Exchangers

The two component cooling heat exchangers are of the shell and straight tube type. River 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 three 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.

9.2.2.4 Residual Heat Removal Loop Components

a) Residual Heat Exchangers

The two 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 tubes and other surfaces in contact with reactor coolant are austenitic stainless steel and the shell is carbon steel.

b) Residual Heat Removal Pumps

The two 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, and for automatic control of bypass flow. Check valves prevent reverse flow through the residual heat removal pumps.

Remotely operated stop valves with pressure interlocks isolate the residual heat removal loop from 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.

9.2.2.5 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 of 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.

9.3 SAMPLING SYSTEM

9.3.1 DESIGN BASIS

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

9.3.2 SYSTEM DESIGN AND OPERATION

The Sampling System, shown in Figure 9-3 is designed to provide the 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 adjustments, 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 sample lines which are normally inaccessible or which require frequent sampling are sampled by means of permanently installed tubing leading to a central sampling room. These samples pass through a delay coil for decay of short-lived radioactive isotopes. The reactor coolant is cooled as it flows through the sample heat exchanger and coolant pressure is reduced by a pressure reducing valve located upstream of the low pressure header. The reactor coolant then flows to the volume control tank through a purge line until sufficient purge volume has passed to permit collection of a representative sample. A portion of the flow is then directed into the sample sink where the sample is collected. Reactor coolant dissolved gas samples are collected in a sample vessel.

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. Samples originating downstream from the junction of the boric acid solution and demineralized water mixing point in the Chemical and Volume Control System pass through a separate sample line to the sample sink.

Gaseous samples from the volume control tank of the Chemical and Volume Control System and the pressurizer relief tank 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.

Reactor coolant liquid and steam sample lines inside the reactor containment are manifolded into a single line which connects to the delay coil. Each of these connections to the Reactor Coolant System has a remotely operated isolation valve located close to the source of reactor coolant.

Because the pressurizer steam phase and volume control tank gas phase samples 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.

9.3.3 COMPONENTS

a) Sample Heat Exchanger

The sample heat exchanger reduces the reactor coolant sample temperature before it reaches the sample vessels. This unit consists of a coiled section of jacketed tubing. The reactor coolant sample stream flows through the inner coil and component cooling water from the Auxiliary Coolant System circulates through the jacket. All parts of the heat exchanger contacting the reactor coolant are austenitic stainless steel. The inlet and outlet ends have socket-weld joints for connection to the high pressure sample line.

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) Reactor Coolant Sample Vessel

The reactor coolant sample vessel is used to obtain reactor coolant liquid samples and condensed pressurizer steam space samples for dissolved gas content determination. 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 as indicated on Figure 9-3.

A check valve prevents excessive reverse flow of gas 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 System is 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 insure sub-critical 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 received and stored in racks in the new fuel storage area. New fuel is delivered to the reactor by lowering it into the spent fuel pit and taking it through the transfer system. Alternatively, the 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

Major structures required for refueling are as follows:

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.

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 after reactor cooldown but 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 emergency 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 3 ft. wide 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.

The pit is designed to accommodate a total of one and one-third cores. Space is provided in the pit for 257 fuel assemblies, 92 rod cluster control assemblies and the spent fuel shipping cask.

Spent fuel assemblies are handled by a long handled tool suspended from an overhead crane and manipulated by an operator standing on a movable bridge over the pit.

The spent fuel storage pit is constructed of reinforced concrete having walls 6 ft. - 3 in. thick. The entire interior basin face and transfer canal is lined with stainless steel plate.

A storage rack is provided to hold spent fuel assemblies and is erected on the pit floor. Fuel assemblies will be placed in vertical cells, continuously grouped in parallel rows 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. Control rod clusters are stored in place inside the spent fuel assemblies.

9.4.3.4 New Fuel Storage and Decontamination Facilities

New fuel assemblies and control rods are stored in a separate area whose location facilitates the unloading of new fuel assemblies or control rods from trucks. This storage vault is designed to hold 70 new fuel assemblies and 25 rod cluster control assemblies in specially constructed racks and is utilized primarily for the storage of the one-third replacement core. The assemblies which make up the remaining two-third of the first core will be stored in the spent fuel pit which otherwise remains unused until the time of first refueling. The new fuel assemblies are moved into place on a fork lift truck and 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. In the equipment pit, cask handling and other tools can be cleaned and decontaminated, this equipment pit being essentially a stainless steel tray. In the cask decontamination pit, the outside surfaces of the cask are decontaminated, if required, by using steam, water, detergent solutions, and manual scrubbing to the extent required. When monitored as clean, the cask is removed by the auxiliary building crane and loaded onto a truck.

9.4.4 FUEL HANDLING EQUIPMENT

Major equipment required for refueling is as follows:

9.4.4.1 Reactor Vessel Stud Tensioner

The stud tensioner is a hydraulically operated (oil as the working fluid) device provided to permit pre-loading 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^{o} 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. This procedure is used 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 operating instructions. In addition, micrometers are provided as a backup 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 rectilinear bridge and trolley crane with a vertical mast extending down into the refueling water. The bridge spans the reactor cavity and runs on rails set into the floor along the edge of the reactor 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 out of 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 walkway spanning the spent fuel pit. The fuel assemblies are moved within the spent fuel pit by means of the overhead crane and the 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 9-4 is an underwater cable 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 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 or blind flange in the transfer tube is closed to seal the reactor containment.

9.4.4.7 Rod Cluster Control Changing Fixture

A fixture 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 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 insured by the refueling procedure:

1) The refueling water and the reactor coolant will contain enough boric acid (~20,000 ppm boric acid) to keep the core subcritical even 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.

Failed fuel cans as described above, or another method and equipment for identifying the individual fuel assembly which contains a failed element shall be furnished when and if fuel failures occur and such equipment is required.