9.0 AUXILIARY AND EMERGENCY SYSTEMS

9.0.1 Summary

The Auxiliary and Emergency Systems are supporting systems required for safe operation and servicing of the Reactor (Chapter 3) and the Reactor Coolant System (Chapter 4).

In some cases, operation of several systems is required to protect the Reactor and the Reactor Coolant System by controlling system conditions within specified operating limits. Other systems are called upon to operate under emergency conditions.

The systems included in this chapter are:

Chemical and Volume Control System

This system provides for boron injection, chemical additions for corrosion control, reactor coolant clean-up and degasification, reactor coolant make-up, reprocessing of water letdown from the Reactor Coolant System, and reactor coolant pump seal water injection.

Residual Heat Removal System

This system removes residual and sensible heat from the core and reduces the temperature of the Reactor Coolant System during the second phase of plant cool-down.

Spent Fuel Pool Cooling System

This system removes the heat generated by spent fuel elements stored in the spent fuel pool, and maintains spent fuel pool water in clean and clear conditions.

Component Cooling System

This system removes residual and sensible heat from the Reactor Coolant System via the Residual Heat Removal System during plant cooldown, cools the spent fuel pool water and the letdown flow to the Chemical and Volume Control System during power operation, and provides cooling to dissipate waste heat from various primary and secondary plant components.

Sampling Systems

These systems provide the equipment necessary to obtain liquid and gaseous samples from the reactor plant systems.

Fuel Handling System

This system provides for handling fuel assemblies, control rod assemblies, and some core structural components.

Facility Service Systems

These systems include Fire Protection, Service Water, Auxiliary Building and Control Room Ventilation, and Compressed Air Systems.

9.1 APPLICATION OF PLANT DESIGN CRITERIA

The criteria, which apply to auxiliary and emergency systems, are presented in Chapter 14. Those specific attributes, which apply to one of the auxiliary or emergency systems, are listed and discussed in the appropriate system design basis section.

The applicable portions of the Missile Protection Criteria as stated in Sub-Chapter 1.4 apply to Class I equipment in this chapter.

As described in Chapter 7 and justified in Chapter 14, the reactor protection systems are designed to limit reactivity transients to DNBR above minimum allowable values due to any single malfunction in the reactivity control system. Each of the auxiliary cooling systems which serve an emergency function provide sufficient capability in the emergency operational mode to accommodate any single failure of an active component and still function in a manner to avoid risk to the health and safety of the public.

Adequate core cooling and containment heat removal can be maintained in case of gross leakage from either the component cooling system, essential service water system, or the residual heat removal system.

The performance capability of the Residual Heat Removal System under partial components operation, and under accident conditions, is detailed in Chapter 6.

Each of the auxiliary cooling systems which serves an emergency function, provides sufficient capability in the emergency operational mode to accommodate any single failure of an active component and still function in a manner to avoid risk to the health and safety of the public.

9.2 CHEMICAL AND VOLUME CONTROL SYSTEM

The Chemical and Volume Control System, is used to:

a. adjust the concentration of boric acid, i.e., the chemical neutron absorber for reactivity control,

b. maintain the proper water inventory in the Reactor Coolant System,

c. provide the required seal water flow for the reactor coolant pump shaft seals,

d. process reactor coolant effluent for reuse of boric acid and reactor makeup water,

e. maintain the proper concentration of corrosion inhibiting chemicals in the reactor coolant,

f. maintain the reactor coolant activities to within design limits, and

g. provide borated water for safety injection.

The system is also used to fill and hydrostatically test the Reactor Coolant System.

During normal operation, this system also has provisions for supplying the following chemicals:

a. Regenerant chemicals to the evaporator condensate demineralizers. This equipment is not normally used.

b. Hydrogen to the volume control tank.

c. Nitrogen as required for purging the volume control tank.

d. Hydrazine and lithium hydroxide as required via the chemical mixing tank to the charging pumps' suctions.

9.2.1 Design Bases

In addition to the reactivity control achieved by the rod cluster control (RCC) assemblies as detailed in Chapters 3 and 7, reactivity control is provided by the Chemical and Volume Control System (CVCS) which regulates the concentration of boric acid solution neutron absorber in the Reactor Coolant System.

Normal reactivity shutdown capability is provided by control rods with boric acid injection used to compensate for the long term xenon decay transient and for plant cool down. Any time that the plant is at power, the quantity of boric acid retained in the boric acid tanks and ready for injection always exceeds that quantity required to bring the reactor to hot shutdown and to compensate for subsequent xenon decay.

The system is designed to allow for concurrent mixing and subsequent injection of boric acid solution. Thus the CVCS provides extended reactivity hold-down capability.

The reactivity control systems provided are capable of making and holding the core sub-critical for hot standby or hot operating conditions, including those resulting from power changes.

The chemical shim control serves to provide hot shutdown for the reactor as backup to the RCC assemblies.

The sizing of CVCS components and redundancy of its components and flow paths determine the CVCS reactor shutdown capability.

The boric acid solution is transferred from the boric acid tanks by boric acid transfer pumps to the suction of the charging pumps, which inject boric acid into the Reactor Coolant System. Any charging pump and any boric acid transfer pump can be operated from diesel generator power on loss of primary power.

On the basis of the above, the injection of boric acid is shown to afford backup shutdown reactivity capability, independent of control rod clusters which normally serve this function in the short term situation. Shutdown for long term and reduced temperature conditions can be accomplished with boric acid injection using redundant components.

Codes and Classifications

Pressure retaining components (or compartments of components) of the CVCS which are exposed to reactor coolant comply with the following codes:

a. System pressure vessels - ASME Boiler and Pressure Vessel Code, Section III, Class C

b. System valves, fittings and piping - USAS B31.1.

Repair and replacement for pressure retaining components within the code boundary, and their supports, are conducted in accordance with ASME Section XI.

System integrity is assured by conformance to applicable codes listed in Table 9.2-1, and by the use of austenitic stainless steel or other corrosion resistant materials in contact with both reactor coolant and boric acid solutions.

The regenerative and excess letdown heat exchangers are designed as ASME Boiler and Pressure Vessel Code Section III, Class C. This designation is based on the following considerations: a) both heat exchangers can be double isolated from the Reactor Coolant System, b) both exchangers are located inside the containment, and c) both exchangers are protected by a missile barrier.

9.2.2 System Design And Operation

The Chemical and Volume Control System shown in Figures 9.2-1 through 9.2-6 provides a means for the injection of soluble neutron absorber in the form of boric acid solution, chemical additions for corrosion control and reactor coolant cleanup and degasification. This system also provides a means to add makeup water to the Reactor Coolant System, reprocess water letdown from the Reactor Coolant System, provide seal water injection to the reactor coolant pump seals, and fill and hydrostatically test the Reactor Coolant System.

A cross-tie on the discharge of the CVCS charging pumps, from one unit to the other, provides emergency flexibility. The cross-tie lines contain manual valves which are closed during normal operation.

System components whose design pressure and temperature are less than the Reactor Coolant System design limits are provided with overpressure protective devices.

System discharge from overpressure protective devices is directed to closed systems. Effluents removed from such closed systems are monitored and discharged under controlled conditions.

System design enables post-operational hydrostatic testing to test pressures required by the codes listed in Table 9.2-1.

System Description

During plant operation, reactor coolant flows through the letdown line from one of the reactor coolant loop cold legs on the suction side of the reactor coolant pump and is returned through the charging line on the discharge side of the reactor coolant pump of the same loop. An alternate charging connection is provided on the cold leg of a different loop. Current operating practice includes simultaneous use of both the normal and alternate charging connections. This practice has been adopted to address thermal stress concerns in piping connected to the reactor coolant system. An excess letdown line is also provided as an alternate in case the normal letdown circuit is inoperative.

Each of the CVCS connections to the Reactor Coolant System has an isolating valve. In addition, a check valve is located downstream of each charging line isolating valve. Reactor coolant entering the Chemical and Volume Control System flows through the shell side of the regenerative heat exchanger where its temperature is reduced. The coolant then flows through a letdown orifice which reduces the coolant pressure. The cooled, low pressure water leaves the reactor containment and enters the auxiliary building where it undergoes a second temperature reduction in the tube side of the letdown heat exchanger followed by a second pressure reduction by the low pressure letdown valve. After passing through one of the mixed bed demineralizers, where ionic impurities are removed, coolant flows through the reactor coolant filter and enters the volume control tank through a spray nozzle.

Hydrogen is manually supplied to the vapor space in the volume control tank (VCT) which is predominantly hydrogen and water vapor. A self-regulating valve, or (Unit 2 only) manual bypass valve, is used to control hydrogen supply as determined by VCT pressure. The hydrogen within the tank is, in turn, the supply source to the reactor coolant. Fission gases are removed from the system by venting the volume control tank to the Waste Disposal System prior to a cold or refueling shutdown.

To enter the Reactor Coolant System the coolant flows from the volume control tank to the charging pumps which raise the pressure above that in the Reactor Coolant System. The coolant then enters the containment, passes through the tube side of the regenerative heat exchangers, and returns to the Reactor Coolant System. A portion of the high pressure charging flow is filtered and injected into the reactor coolant pumps between the pump impeller and the shaft seal so that the seals are not exposed to particulate matter in the reactor coolant. Part of the flow cools the lower radial bearing and enters the Reactor Coolant System through a labyrinth seal on the pumps shaft. The remainder, which is the shaft seal leakage flow, is filtered, cooled in the seal water heat exchanger and returned to the suction of the charging pumps.

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 returns to the suction of the charging pumps through the excess letdown and seal water heat exchangers.

The cation bed demineralizer, located downstream of the mixed bed demineralizers, is used intermittently to control cesium activity in the coolant and also to remove excess lithium, which is formed from the B^{10} (n, α) Li^7 reaction.

Boric acid is dissolved in hot water in the batching tank to a concentration of approximately four weight percent. The batching tank is jacketed to permit heating of the batching tank solution with low-pressure steam. One of four boric acid transfer pumps is used to transfer the batch to the boric acid tanks. The batching tank and the boric acid tanks are shared by Units 1 and 2. Small quantities of boric acid solution are metered from the discharge of an operating boric acid transfer pump for blending with the water supplied to makeup for normal leakage, or for increasing the reactor coolant boron concentration during normal operation. Electric immersion heaters maintain the temperature of the solution in the boric acid tanks high enough to prevent precipitation.

During plant startup, normal operation, load reductions and shutdowns, liquid effluents containing boric acid flow from the Reactor Coolant System through the letdown line and are collected in the holdup tanks (shared by Units 1 and 2) or the Volume Control Tank. As liquid enters the holdup tanks, the nitrogen cover gas is displaced to the gas decay tanks in the Waste Disposal System through the waste vent header. If the gas becomes highly oxygenated, a provision exists for bypassing the waste vent header and discharging the gas to the monitored plant vent, provided tank gas samples are found acceptable for release. The concentration of boric acid in the letdown fluid to the holdup tanks varies throughout core life from the refueling concentration to essentially zero at the end of the core cycle. A recirculation pump is provided to transfer liquid from one holdup tank to another. Contents of the CVCS holdup tanks may be discharged to the environment via the waste disposal system (Chapter 11).

Liquid effluent in the holdup tanks is generally processed as a batch operation through a recycle processing train for boric acid recovery. This liquid is pumped by the boric acid evaporator feed pumps through the evaporator feed ion exchangers (shared by Units 1 and 2) which remove cations (primarily lithium and long-lived cesium) and anions. The liquid then flows through the ion exchanger filter, and into the gas stripper section of the boric acid evaporator where dissolved gases are removed from the liquid. These gases are vented to the Waste Disposal System.

The liquid effluent from the gas stripper section enters the boric acid evaporator. The vapor produced in the boric acid evaporator leaves the evaporator condenser and is pumped through a condensate cooler where the distillate is cooled to the operating temperature of the evaporator condensate demineralizers. The evaporator condensate demineralizers are not normally used. When the evaporator condensate demineralizers are used then the non-volatile evaporator carry over is removed by one of the two evaporator condensate demineralizers. Evaporator condensate flows through the condensate filter and accumulates in one of the two CVCS monitor tanks (shared by Units 1 and 2). The other two monitor tanks are used for radioactive waste disposal. The dilute boric acid solution originally in the boric acid evaporators is concentrated to approximately four weight percent boric acid.

Subsequent handling of the condensate is dependent on the results of sample analysis of the monitor tank contents. Discharge from the monitor tanks may be pumped by the monitor tank drain pumps to the primary water storage tank, recycled through the evaporator condensate demineralizers, returned to the holdup tanks for reprocessing in the evaporator train or, if the sample analysis of the monitor tanks contents indicates sufficiently low levels, the contents may be discharged to the environment via the waste disposal system (Chapter 11).

Boric acid evaporator bottoms are sampled and then pumped to either the concentrates holding tank, the CVCS holdup tanks or the boric acid tanks as determined by the Shift Manager.

The concentrated solution can also be pumped from the evaporator to the waste disposal system waste evaporator for additional processing for disposal.

The deborating demineralizers can be used intermittently to remove boron from the reactor coolant near the end of core life when boron concentration is low. When the deborating demineralizers are in operation, the letdown stream passes from the mixed bed demineralizers, then through the deborating demineralizers and through the reactor coolant filter and into the volume control tank.

During plant cooldown when the residual heat removal loop is operating and the letdown orifices are not in service, a flow path is provided to remove fission products, corrosion and other impurities. A portion of the flow leaving the residual heat exchangers passes through the letdown heat exchanger, mixed bed demineralizers, reactor coolant filter and volume control tank. The fluid is then pumped via the charging pump through the tube side of the regenerative heat exchanger into the Reactor Coolant System.

Expected Operating Conditions

Tables 9.2-2 and 9.2-3 list the system performance requirements and data for individual system components, respectively. The component data contained in Table 9.2-3 is original equipment design and sizing data. The CCW system has been designed and analyzed to;

a. Operate in the range of 60°F to 105°F, except during periods of cooldown and post-LOCA operation, and

b. Operate at temperatures ≤120°F during cooldown and post-LOCA operation.

Reactor Coolant Activity Concentration

The parameters used in the calculation of the reactor coolant fission product inventory, including the expected coolant cleanup flow rate and the demineralizer effectiveness, are presented with the results of the calculations in Chapter 14. In these calculations the defective fuel rods are assumed to be present at locations uniformly distributed throughout the core. The fission product escape rate coefficients are therefore based upon an average fuel temperature.

Tritium is produced in the reactor from ternary fission in the fuel, irradiation of boron in the burnable poison rods and irradiation of boron, lithium and deuterium in the coolant. A discussion of tritium control is given in Section 9.2.3.

Reactor Makeup Control Modes

The reactor makeup control is designed to operate from the control room by manually pre-selecting makeup composition to the charging pump suction header or the volume control tank in order to maintain the desired operating fluid inventory in the volume control tank and to adjust the reactor coolant boron concentration for reactivity control. The operator can stop the makeup operation at any time in any operating mode by remotely closing the makeup stop valves.

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

a. The primary water storage tank, 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 alternate and emergency makeup; or

d. The chemical mixing tank, which is used to inject small quantities of hydrazine or pH control chemical when necessary.

Makeup for normal plant leakage is regulated by the reactor makeup control, which is set by the operator to blend water from the primary water storage tank with 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.

Makeup

The "automatic makeup" mode of operation of the reactor primary water makeup control provides boric acid solution preset to match the boron concentration in the Reactor Coolant System. The automatic makeup compensates for minor leakage of reactor coolant without causing significant changes in the coolant boron concentration.

Under normal plant operating conditions, the mode selector switch and makeup stop valves are set in "Automatic Makeup Position." The following actions are initiated automatically when a low level signal is received from the volume control tank: 1) the operating boric acid transfer pump is switched to high speed or a boric acid transfer pump is manually switched on from an off position to high speed, 2) the primary water makeup pump starts, 3) the boric acid modulating valve and the primary water modulating valve are actuated, and 4) the valve to suction of charging pumps is opened. The flow controllers then blend the makeup stream according to the preset concentration. This blending causes the volume control tank level to rise. At a preset high level point, the makeup is stopped, the primary water makeup pump stops, the primary water makeup control valve closes, the boric acid transfer pump is returned to low speed operation or is manually switched to an off position, the concentrated boric acid control valve closes and the makeup stop valve to the charging pump suction closes.

The system is also supplied with the capability for a "Manual Makeup" mode of operation which permits the operator to select the flow path, and the rate and quantity of both boric acid and primary water at the same time.

Dilution

The "dilute" mode of operation permits the addition of a pre-selected quantity of primary water makeup at a pre-selected flow rate to the Reactor Coolant System. The operator sets the makeup stop valves to the volume control tank and to the charging pump suction in the closed position, the mode selector switch to "dilute," the primary water makeup flow controller set point to the desired flow rate, sets the reactor primary water makeup batch integrator to the desired quantity and initiates system start. This opens the primary water makeup control valve to the volume control tank and starts a primary water makeup pump which will deliver primary makeup water to the volume control tank. From there the water goes to the charging pump suction header. Excessive rise of the volume control tank water level is prevented by automatic actuation (by the tank level controller) of a three-way diversion valve which routes the reactor coolant letdown flow to the holdup tanks. When the preset quantity of primary water makeup has been added, the batch integrator causes the primary water makeup pump to stop and the primary water makeup control valve to close.

The system is also supplied with the capability for an "Alternate Dilution" mode of operation which permits the operator to deliver dilution flow to the volume control tank and/or directly to the suction of the charging pump to allow quicker dilution than the dilute mode.

Boration

The "borate" mode of operation permits the addition of a pre-selected quantity of concentrated boric acid solution at a pre-selected flow rate to the Reactor Coolant System. The operator sets the makeup stop valves to the volume control tank and to the charging pump suction in the closed position, the mode selection switch to "borate," the concentrated boric acid flow controller set point to the desired flow rate, the concentrated boric acid batch integrator to the desired quantity, and initiates system start. The following actions are initiated automatically when a signal is received from the batch integrator of the reactor makeup control: 1) The boric acid transfer pump is switched to high speed, 2) the boric acid modulating valve is actuated, and 3) the valve to suction of charging pump is opened. This will cause delivery of a four weight percent boric acid solution to the charging pump suction header. The total quantity added in most cases will be so small that it will have only a minor effect on the volume control tank level. When the preset quantity of concentrated boric acid solution is added, the batch integrator causes the boric acid transfer pump to return to low speed operation and closes the boric acid modulating valve and the makeup stop valve to the suction of the charging pumps. In the event of a volume control tank low-low level signal, the suction of the charging pumps is automatically aligned to take suction from the refueling water storage tank.

The amount of boric acid in the boric acid tank is sufficient to maintain the reactor subcritical by the necessary shutdown margin at hot conditions following a reactor trip from all credible operating conditions. The flow rate of boric acid from the boric acid tank is sufficient to follow the highest burnout rate of xenon following reactor startup from peak xenon conditions.

Sufficient volume of boric acid is available in the RWST to borate the reactor to cold shutdown conditions and maintain the reactor subcritical by the necessary shutdown margin following a reactor trip from all credible operating conditions. Plant operating procedures ensure the necessary shutdown margin is maintained at all times during the cooldown process. Additionally, the flowrate of boric acid from the RWST is sufficient to compensate for the maximum xenon burnout following a reactor startup from peak xenon conditions, which bounds the flow rate required to compensate for the xenon decay during a reactor shutdown from 100% rated thermal power at peak xenon conditions.

The system is also supplied with the capability for an “Emergency Boration” mode of operation to initiate rapid boration to restore shutdown margin in the event an abnormal condition results in an unexplained or uncontrolled reactivity increase.

Alarm Functions

The reactor makeup control is provided with alarm functions to call the operator's attention to the following conditions:

a. Deviation of reactor primary water makeup flow rate from the control set point.

b. Deviation of concentrated boric acid flow rate from control set point.

c. Low level (makeup initiation point) in the volume control tank when the primary water makeup control selector is not set for the automatic makeup control mode.

d. Low level (between makeup initiation point and automatic alignment charging pump suction to refueling water storage tank) in the volume control tank to allow the operator to manually initiate makeup prior to refueling water automatic alignment.

Charging Pump Control

Positive Displacement Charging Pump∗

The positive displacement charging pump has a variable speed drive and supplies charging flow to the Reactor Coolant System. The speed of this pump can be controlled manually, or automatically by pressurizer level. During load changes the pressurizer level set point varies automatically with T_{avg}, compensating partially for the expansion or contraction of reactor coolant associated with T_{avg} changes. Charging pump speed will not change rapidly with pressurizer level control. If the pressurizer level increases, the speed of the pump decreases; conversely, if the level decreases, the speed increases. If the positive displacement charging pump reaches the high speed limit, it becomes necessary to place a centrifugal pump in operation to provide the higher flow capacity and to remove the positive displacement pump from service.

To ensure that the charging pump flow is always sufficient to meet both the seal water and minimum charging flow requirements, the pump has a variable control stop which prevents pump flow lower than the specified minimum. The control stop is variable to permit higher minimum flow limits to be set if mechanical seal leakage increases during plant life.

Centrifugal Charging Pumps

The centrifugal pumps are constant speed pumps with flow control accomplished by a modulating valve in the pump discharge line. When the positive displacement pump is in operation, this control valve is in the wide open position.

A flow transmitter on the charging line upstream of the regenerative heat exchanger transmits a signal to a controller which regulates a modulating valve in the charging line to maintain a preset charging flow. A pressurizer water level error signal resets the charging flow set point to take corrective action. The response of the charging line modulating valve to changes in the flow control signal is normally maintained slow to reduce charging flow fluctuations due to short term pressurizer level transients.

Components

A summary of principal component data is given in Table 9.2-3.

∗ The positive displacement charging pumps are not currently used for plant operations.

Regenerative Heat Exchanger

The regenerative heat exchanger is designed to recover heat from the letdown flow by heating the charging flow, which minimizes reactivity effects due to insertion of cold water and reduces thermal shock on the charging penetrations into the reactor-coolant-loop piping.

The design also considers the limit of difference in temperature, which occurs during periods when letdown flow exceeds charging flow by a greater margin than at normal letdown conditions.

The letdown stream flows through the shell of the regenerative heat exchanger and the charging stream flows through the tubes. The unit is made of austenitic stainless steel, and is of all welded construction. It is a multi-shell U tube type heat exchanger using three shells.

Letdown Orifices

One of the three letdown orifices controls flow of the letdown stream during normal operation and reduces the pressure to a value compatible with the letdown heat exchanger design. Two of the letdown orifices are designed to pass normal letdown flow. The third orifice is designed to be used in conjunction with one normal letdown flow orifice to attain maximum purification flow at normal reactor coolant system operating pressure. The orifices are placed in and taken out of service by remote manual operation of their respective isolation valves. The standby orifice may be used in parallel with the normally operating orifice in order to increase letdown flow when the reactor coolant system pressure is below normal. This arrangement provides a full standby capacity for control of letdown flow. Each orifice is an austenitic pipe containing a bored corrosion and erosion resistant insert.

Letdown Heat Exchanger

The letdown heat exchanger cools the letdown stream to the operating temperature of the mixed bed demineralizers. Reactor coolant flows through the tube side of the exchanger while component cooling water flows through the shell. The letdown stream outlet temperature is automatically controlled by a temperature control valve in the component cooling water outlet stream. The unit is a multiple-tube-pass heat exchanger. All surfaces in contact with the reactor coolant are austenitic stainless steel, and the shell is carbon steel.

Mixed Bed Demineralizers

Two flushable mixed bed demineralizers assist in maintaining reactor coolant purity. A Li^7 cation resin and a hydroxyl form anion resin are charged into one demineralizer. A hydrogen cation resin and hydroxyl form anion resin are charged into the other demineralizer. This demineralizer is used to remove Li^7 whereas the other will not. Both forms of resin remove fission and corrosion products. The resin bed is designed to reduce the concentration of ionic isotopes in the purification stream except for cesium, yttrium and molybdenum, by a minimum factor of 10, assuming one percent of fuel containing clad defects.

Each demineralizer is sized to accommodate the maximum letdown flow. One demineralizer serves as a standby unit for use if the operating demineralizer becomes exhausted during operation.

The demineralizer vessels are provided with suitable connections to facilitate resin replacement when required. The vessels are equipped with a resin retention screen. Each demineralizer has sufficient capacity for approximately one core cycle with one percent defective fuel rods.

Cation Bed Demineralizer

A flushable cation resin bed in the hydrogen form is located downstream of the mixed bed demineralizers and is used intermittently to control the concentration of Li^7 which builds up in the coolant from the B^{10} (n, α) Li^7 reaction. The demineralizer also has sufficient capacity to maintain the cesium-137 concentration in the coolant below 1.0 μci/cc with 1% defective fuel. The demineralizer is used intermittently to control cesium.

The demineralizer vessel is provided with suitable connections to facilitate resin replacement when required. The vessel is equipped with resin retention screens. The cation bed demineralizer has sufficient capacity for approximately one core cycle with one percent defective fuel rods.

Reactor Coolant Filter

The filter collects resin fines and particulates from the letdown stream. The vessel is provided with connections for draining and venting. The nominal flow capacity of the filter is equal to the maximum purification flow rate. Disposable filter elements are used.

Volume Control Tank

The volume control tank is an operating surge volume compensating in part for reactor coolant releases from the Reactor Coolant System as a result of level changes. The volume control tank also acts as a head tank for the charging pumps and reservoir for the leakage from the reactor coolant pump controlled leakage seal. Overpressure of hydrogen gas is maintained in the volume control tank to control the hydrogen concentration in the reactor coolant at 25 to 50 cc per kg of water (STP).

A spray nozzle is located inside the tank on the inlet line from the reactor coolant filter. This spray nozzle provides intimate contact to equilibrate 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 collected in the tank.

Charging Pumps

Three charging pumps are provided for injecting coolant into the Reactor Coolant System. Two are centrifugal pumps and the third is a positive displacement pump equipped with variable speed drive. All parts in contact with the reactor coolant are fabricated of austenitic stainless steel or other material of adequate corrosion resistance. The centrifugal pump packing glands and positive displacement pump stuffing box are provided with leakoffs to collect reactor coolant before it can leak to the outside atmosphere. Pump leakage is piped to the drain header disposal. The pump design prevents lubricating oil from contaminating the charging flow. The integral discharge valves on the positive displacement pump act as check valves.

The positive displacement pump is designed to provide the full charging flow and the reactor coolant pump seal water supply during normal seal leakage and normal letdown.∗ The centrifugal pumps have a higher flow capacity and are currently used in normal plant operation. Each pump was designed to provide charging and seal injection flows with normal letdown flow (75 gpm) or maximum letdown flow (120 gpm), provided that the RCS cold leg backpressure is at normal operating conditions, and provided that the charging pump minimum flow path is isolated during maximum letdown flow.

The positive displacement charging pump is designed to be used to hydrotest the Reactor Coolant System.

Either the positive displacement charging pump or a centrifugal charging pump can take suction from the volume control tank and discharge to the normal charging and reactor coolant pump seal water injection paths. When the positive displacement pump is not used, one of the centrifugal charging pumps is operated.* The flow paths remain the same but flow control is accomplished by a modulating valve on the discharge side of the centrifugal pumps. For periods when maximum letdown or purification flow is required, a centrifugal pump is operated to

∗ The positive displacement charging pumps are not currently used for plant operations.

provide the necessary flow. The centrifugal charging pumps also serve as high head safety injection pumps in the Emergency Core Cooling System (Chapter 6).

Chemical Mixing Tank

The primary use of the chemical mixing tank is in the preparation of caustic solutions for pH control and hydrazine for oxygen scavenging.

The capacity of the chemical mixing tank is determined by the quantity of 35% hydrazine solution necessary to increase the hydrazine concentration in the reactor coolant by 10 ppm. This capacity is more than sufficient to permit the preparation of the appropriate quantity of pH control chemical solution for the Reactor Coolant System.

Excess Letdown Heat Exchanger

The excess letdown heat exchanger is designed to cool the amount of reactor coolant letdown equal to the nominal injection rate through the reactor coolant pump labyrinth seal, when the normal letdown path is not usable. The letdown stream flows through the tube side and component cooling water is circulated through the shell side. All surfaces in contact with reactor coolant are austenitic stainless steel and the shell is carbon steel. All tube joints are welded.

Seal Water Heat Exchanger

The seal water heat exchanger removes heat from several sources; the reactor coolant pump seal water returning to the volume control tank, the reactor coolant discharge from the excess letdown heat exchanger and the centrifugal charging pump by-pass flow. Reactor coolant flows through the tubes and component cooling water is circulated through the shell side. The tubes are welded to the tube sheet to prevent leakage in either direction and undesirable contamination of the reactor coolant or component cooling water. All surfaces in contact with reactor coolant are austenitic stainless steel and the shell is carbon steel.

The unit is designed to cool the excess letdown flow, the pump seal water flow and the centrifugal charging pump by-pass flow to the temperature normally maintained in the volume control tank.

Seal Water Filter

This filter collects particulates from the reactor coolant pump seal water return and from the excess letdown heat exchanger flow. The filter is designed to pass the sum of the excess letdown flow and the maximum design leakage from the reactor coolant pump seals. The vessel is provided with connections for draining and venting. Disposable filter elements are used.

Seal Water Injection Filters

The filter collects particulates from the reactor coolant pump seal water inlet. Two filters are provided in parallel, each sized for the maximum design pump seal flow rate. The vessel is provided with connections for draining and venting. Disposable filter elements are used.

Boric Acid Filter

The boric acid filter collects particulates from the boric acid solution being pumped to the charging pump suction line or boric acid blender. The filter is designed to pass the design flow of two boric acid transfer pumps operating simultaneously. The filter elements are disposable cartridges. Provisions are included for venting and draining the filter.

Boric Acid Tanks

Three boric acid tanks are shared by Units 1 and 2. The total boric acid tankage stores sufficient boric acid solution, recovered from the recycle processing train or mixed in the batching tank, for simultaneous hot shutdown shortly after full power operation is achieved. One tank provides sufficient boric acid solution for hot shutdown even if the most reactive RCC assembly is not inserted. One tank supplies boric acid for each reactor coolant makeup system during normal and emergency operations, while the third tank serves as a spare.

The concentration of boric acid solution in storage is maintained between 3.5 and 4.0% by weight. Periodic manual sampling and corrective action, if necessary, insures that these limits are maintained. As a consequence, measured amounts of boric acid solution can be delivered to the reactor coolant to control the chemical poison concentration. The combination overflow and breather vent connection has a water loop seal to minimize vapor discharge during storage of the solution.

Batching Tank

The batching tank (shared by both units) is sized to hold one week's makeup supply, per unit, of boric acid solution for transfer to the boric acid tanks. The basis for makeup is an arbitrary reactor coolant leakage of 1/2 gpm at beginning of core life. The tank may also be used for solution storage.

A local sampling point is provided for verifying the solution concentration prior to transferring it to the boric acid tank. The tank is provided with an agitator to improve mixing during batching operations. The tank is provided with a steam jacket for heating the boric acid solution to 120°F.

Boric Acid Tank Heaters

Each of two electric immersion heaters in each boric acid tank maintains the temperature of the boric acid solution from 105°F to 120°F with ambient air temperature of 40°F, thus ensuring a temperature in excess of the solubility limit. The solubility limit for 4.0 weight percent boric acid is reached at a temperature of 58°F. This temperature is sufficiently low that the normally expected ambient temperatures within the auxiliary building will maintain boric acid solubility. Heaters remain in place for manual or automatic operation in the event auxiliary building ambient temperature falls below the Technical Specification requirement. The heaters are sheathed in austenitic stainless steel.

Boric Acid Transfer Pumps

Two horizontal, centrifugal, two speed pumps with mechanical seals are available per unit. Although not required, one pump may be aligned to run continuously at low speed to provide recirculation of the boric acid system and the boric acid tank. The second pump can be aligned with the shared boric acid tank and is considered as a standby pump, with service being transferred as operation requires. This second pump also intermittently circulates fluid through the shared tank. Automatic initiation of the reactor coolant makeup system will align the running pump for high speed operation to provide normal makeup of boric acid solution as required. Manual operation of the boric acid transfer pumps (i.e., starting an inactive pump) can also be used to provide reactor coolant makeup as necessary. For emergency boration, supplying of boric acid solution to the suction of the charging pump can be accomplished by manually choosing either fast or slow speed and actuating either or both pumps. The transfer pumps also function to transfer boric acid solution from the batching tank to the boric acid tanks.

The design capacity of each pump is equal to the normal letdown flow with the capacity of both pumps being equivalent to the normal design capacity of one centrifugal charging pump. The design discharge pressure is sufficient to overcome any pressures which may exist in the suction manifold of the charging pumps (volume control tank relief valve setting). In addition to the automatic actuation by the makeup control system, and manual actuation from the main control board, these pumps may also be controlled locally at a local control center.

All parts in contact with the solution are of austenitic stainless steel. Connections are provided to enable the use of these pumps to flush the equipment and piping with primary water.

Boric Acid Blender

The boric acid blender promotes thorough mixing of boric acid solution and primary water makeup for the reactor coolant makeup circuit. The blender consists of a conventional pipe fitted with a perforated tube insert. The blender decreases the pipe length required to homogenize the mixture for taking a representative local sample.

Holdup Tanks

Two pairs of holdup tanks plus a single tank are provided to receive and hold for processing the letdown fluid from the Reactor Coolant System. Each pair of tanks has a crosstie between the liquid spaces and between the gas spaces of each tank, making each pair, in effect, a single tank. The single tank is half the capacity of each pair of tanks. The system is so arranged that normally one pair of tanks serves one unit, a second serves the other unit and the single tank is a spare to provide additional storage when necessary. One pair of tanks (or the single tank) at a time is processed by the boric acid evaporator. The total liquid capacity of the tanks is greater than three Reactor Coolant System volumes. The tanks are constructed of austenitic stainless steel.

Boric Acid Reserve Tank

The boric acid reserve tank provides a reserve supply of boric acid solution to augment the boric acid tanks. The tank augments the boric acid tanks as both a source and receiver of boric acid solution. This quantity of boric acid is not required by the Technical Specifications but provides additional operating margin for the boric acid makeup system and increases system reliability. The contents of the reserve tank may be mixed with one of the boric acid evaporator feed pumps. The boric acid evaporator feed pump supplies boric acid from the reserve tank to the boric acid tanks, the boric acid evaporator feed ion exchangers, ion exchange filter, boric acid evaporator, concentrates filter and concentrates holding tank transfer pumps. The contents of the reserve tank can also be processed via this path and returned to the reserve tank. Units 1 and 2 share the reserve tank. The tank is constructed of austenitic stainless steel.

Holdup Tank Recirculation Pump

The recirculation pump is used to mix the contents of a pair of holdup tanks for sampling or to transfer the contents to another pair of holdup tanks. The pump may also be used to fill the spent fuel pit transfer canal from the holdup tanks. The wetted surface of this pump is constructed of austenitic stainless steel.

Boric Acid Evaporator Feed Pumps

The three feed pumps (shared by both units) supply feed to the boric acid evaporator trains from the holdup tanks. The capacity of each pump is equal to the boric acid evaporator capacity. The non-operating pump is a standby and is available for operation in the event the operating pump malfunctions. These canned centrifugal pumps are constructed of austenitic stainless steel.

Evaporator Feed Ion Exchangers

Four flushable evaporator feed ion exchangers (shared by both units) remove cations (primarily cesium and lithium) and anions from the holdup tank effluent. Two of the demineralizers are of the mixed bed type and the other two are of the cation bed type. One of each type are in series in each processing train.

The design flow rate is equal to the boric acid evaporator processing rate. The demineralizer vessels are constructed of austenitic stainless steel and are provided with suitable connections to facilitate resin replacement when required. The vessels are equipped with resin retention screens.

Ion Exchanger Filters

These filters collect resin fines and particulates from the evaporator feed ion exchangers. The vessels are made of austenitic stainless steel, and are provided with connections for draining and venting. Disposable filter elements are used. The design flow capacity is equal to or greater than the boric acid evaporator flow rate.

Boric Acid Evaporators

A boric acid evaporator is provided which will process 30 gpm of dilute radioactive boric acid and produce distillate and concentrated boric acid stripped of the radioactive gases. The other boric acid evaporator and associated equipment has been converted to a radioactive waste evaporator as described in Chapter 11. Radioactive gas stripping is achieved by passing heated feed through packed towers employing stripping steam which removes nitrogen, hydrogen and fission gases from the feed and is designed to reduce the influent gas concentration by a factor of 10^5.

Evaporator Condensate Demineralizers

A demineralizer removes low-level contaminants from the evaporator condensate. The resin may be anion, cation or mixed bed, and is selected based on the condensate chemistry profile. The other demineralizer (anion) has been converted to a radioactive waste disposal function as described in Chapter 11. Facilities are provided for regeneration of anion resin. When regeneration is no longer feasible, the resin is flushed to the spent resin storage tank. Each demineralizer is sized for a flow rate equal to the evaporator flow rate. The demineralizer vessel is made of all-welded austenitic stainless steel, and is equipped with a resin retention screen. This equipment is not normally used.

Condensate Filter

The filter collects resin fines and particulates from the boric acid evaporator condensate stream. The vessel is made of austenitic stainless steel, and is provided with connections for draining and venting. Disposable filter elements are used. The design flow capacity of the filter is equal to the total installed boric acid evaporator flow rate.

Monitor Tanks

Two shared monitor tanks permit continuous operation of the evaporator train. When one tank is filled, the contents are analyzed and either reprocessed, discharged to the Waste Disposal System or pumped to the primary water storage tank. The other two monitor tanks have been converted to a radioactive waste disposal function as described in Chapter 11.

Each of the tanks has sufficient capacity to hold the condensate produced during 12 hours of operation from an evaporator at full output with only two lab analyses per day.

The tanks are fitted with a nylon, rubber-coated membrane to prevent absorption of oxygen by the water stored in the tank. The portion of the tank above the membrane is vented to the auxiliary building atmosphere.

Monitor Tank Pumps

Two shared monitor tank pumps discharge water from the monitor tanks. Each pump is sized to empty a monitor tank in approximately 3 hours. The pumps are constructed of austenitic stainless steel.

Deborating Demineralizers

When required, two anion demineralizers remove boric acid from the Reactor Coolant System fluid. The demineralizers are provided for use near the end of a core cycle, but can be used at any time when boron concentration is low. Hydroxyl based ion-exchange resin is used to reduce Reactor Coolant System boron concentration by releasing a hydroxyl ion when a borate ion is absorbed. Facilities are provided for regeneration. When regeneration is no longer feasible, the resin is flushed to the spent resin storage tank.

Each demineralizer is sized to remove the quantity of boric acid that must be removed from the Reactor Coolant System to maintain full power operation near the end of core life.

Concentrates Filter

The filter removes particulates from the evaporator concentrates. Design flow capacity of the filter can accommodate the total installed boric acid evaporator capacity. The vessel is provided with connections for draining and venting. Disposable filter elements are used.

Concentrates Holding Tank

The shared concentrates holding tank is sized to hold approximately the production of concentrates from one batch from both evaporators. The tank is supplied with an electrical heater which prevents boric acid precipitation.

Concentrates Holding Tank Transfer Pumps

Two shared holding tank transfer pumps discharge boric acid solution from the concentrates holding tank to the boric acid tanks. The canned centrifugal pumps are sized to approximately match the capacity of the boric acid evaporator concentrates pumps or to pump out the contents of the tank in approximately 1 hour. The wetted surfaces are constructed of austenitic stainless steel.

Electrical Heat Tracing

The boric acid concentration for Units 1 and 2 has been reduced to 4% and no longer requires heat trace. The minimum operating temperature for Units 1 and 2 boric acid piping is 63°F. The piping, valves, line-mounted instrumentation, and components, which normally contain boric acid solution, are monitored to ensure ambient temperatures are above 63°F. The alarmstats, piping temperature sensors/capillary, cabling and heat trace alarm panels have been abandoned in place or removed . Power to the heat trace circuits is determinated and abandoned in place.

Electrical heat tracing is provided for sections of piping, valves and equipment for freeze protection purposes where needed.

Alternate methods of flushing or heating are provided for:

a. Lines which may transport concentrated boric acid but are subsequently flushed with reactor coolant or other liquid of low boric acid concentration during normal operation.

b. The boric acid tanks which are provided with immersion heaters.

c. The batching tank which is provided with a steam heated jacket.

d. The concentrates holding tank, which is provided with an immersion heater.

Valves

Isolation valves are provided for 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 a locked or sealed open valve and a spring loaded check valve bypassing the charging line isolation valves.

Piping

Chemical and Volume Control System piping handling radioactive liquid is austenitic stainless steel. Piping joints and connections are welded, except where flanged connections are required to facilitate equipment removal for maintenance and hydrostatic testing.

9.2.3 System Design Evaluation

Availability and Reliability

A high degree of functional reliability is assured in the Chemical and Volume Control System by providing standby components where performance is vital to safety and by assuring fail-safe response to the most probable mode of failure.

The Chemical and Volume Control System has three high pressure charging pumps, which are capable of supplying the required reactor coolant pump seal and makeup flow.

Aside from those components that are also part of the Emergency Core Cooling System (Chapter 6), the Chemical and Volume Control System is not required to function during a loss-of-coolant accident.

The generation of a safety injection signal, occasioned by a loss-of-coolant accident, automatically closes the motor-operated valves in the outlet line of the volume control tank and in the normal charging line thus isolating the Chemical and Volume Control System from the safety injection path. The letdown line and reactor coolant pump seal water return line are isolated at the containment boundary by valves which automatically close as a result of high containment pressure caused by a loss-of-coolant accident. The centrifugal charging pumps are also automatically started and commence pumping into the Reactor Coolant System immediately on alignment of flow paths.

Control of Tritium

Tritium is produced in the reactor coolant because of irradiation of boron, lithium, and deuterium in the coolant. Also as a design basis, 30% of the tritium produced in the fuel rods and in the burnable poison rods (initial cycle only) is assumed to be released to the coolant. Recent operating experience with zircaloy cores indicates that the amount of tritium released to the coolant is substantially less than the design basis (about 1% instead of 30%).

The Chemical and Volume Control System is used to control the concentration of tritium in the Reactor Coolant System. Essentially all of the tritium is in chemical combination with oxygen as a form of water. Therefore, any leakage of coolant to the containment atmosphere carries tritium in the same proportion as it exists in the coolant. Thus, the level of tritium in the containment atmosphere, when it is sealed from outside air ventilation, is a function of tritium level in the reactor coolant, the relative humidity of the air in the containment and the presence of leakage other than reactor coolant as a source of moisture in the containment air.

There are two major considerations with regard to the presence of tritium in the reactor coolant:

a. Possible plant personnel hazard during access to the containment must be limited. Leakage of reactor coolant during operation with a closed containment causes an accumulation of tritium in the containment atmosphere.

b. Undue public hazard due to release of tritium to the plant environment must be avoided.

Both of these criteria are met in this plant.

The tritium concentration recommended as an upper limit in the reactor coolant is 2.5 µci/cc (at 580°F coolant temperature). This value was chosen to assure that the tritium concentration in the atmosphere of the containment will be low enough to permit access without protective equipment. The concentration of tritium in the reactor coolant is maintained at an acceptable level by discharging part of the condensate from the boric acid recovery process to the Waste Disposal System (Chapter 11). The design basis for the monitor tanks is to process for release four RCS volumes per year for tritium control.

Leakage Provisions

Any undecayed tritium in the reactor coolant will eventually be released via the Waste Disposal System to the plant discharge stream. In the plant discharge stream, the tritium (and other liquid radwastes) is mixed with the plant circulating water flow.

Quality control of the material and installation of the Chemical and Volume Control System valves and piping which are designated for radioactive service is provided, in order to essentially eliminate leakage to the atmosphere.

The components designated for radioactive service are provided with welded connections to prevent leakage to the atmosphere. However, flanged connections are provided on each charging pump suction and discharge, on each boric acid pump suction and discharge, on the relief valves inlet and outlet, on three-way valves and on the flow meters to permit removal for maintenance.

The positive displacement charging pump stuffing boxes are provided with leakoffs to collect reactor coolant before it can leak to the atmosphere.

Diaphragm or ball valves are provided where the operating pressure is 200 psi or below and the operating temperature is 200°F or below. Leakage to the atmosphere is essentially zero for these valves.

The CVCS is included in our plant preventive maintenance program. The system is inspected, the leakage measured and repaired as necessary. This program is performed on this system at least once per refueling cycle.

Incident Control

The letdown line and the reactor coolant pumps seal water return line penetrate the reactor containment. The letdown line contains four air-operated valves inside the reactor containment (three in parallel and one in series with the parallel valves) and one air-operated valve outside the reactor containment which are automatically closed by the containment isolation signal.

The reactor coolant pumps seal water return line contains one motor-operated isolation valve inside and one outside the reactor containment which are automatically closed by the containment isolation signal.

The four seal water injection lines to the reactor coolant pumps and the charging line are inflow lines penetrating the reactor containment. Each line contains a check valve inside the reactor containment to provide isolation of the reactor containment should a break occur in these lines outside the reactor containment.

Malfunction Analysis

To evaluate system safety, failures or malfunctions were assumed concurrent with a loss-of-coolant accident, and the consequences analyzed, see Table 9.2-4 and Chapter 14.

If a rupture takes place between the reactor coolant loop and the first isolation valve or check valve, an uncontrolled loss of reactor coolant occurs. The analysis of the loss-of-coolant accident is discussed in Chapter 14.

Should a rupture occur in the Chemical and Volume Control System outside the containment, or at any point beyond the first check valve or remotely operated isolation valve, actuation of the valve would limit the release of coolant and assure continued functioning of the normal means of heat dissipation from the core. For the general case of rupture in the CVCS outside the containment, the largest source of radioactive gases and fluid subject to release is the contents of the volume control tank. The consequences of such a release are considered in Chapter 14.

When the reactor is subcritical, i.e., during cold or hot shutdown, refueling and approach to criticality, the relative reactivity status (neutron source multiplication) is continuously monitored and indicated by intermediate and source range detectors except after the P-6 setpoint is reached after which the source range detectors are de-energized. Any appreciable increase in the neutron source multiplication, including that caused by the maximum physical boron dilution rate of approximately 680 ppm per hour, is slow enough to give ample time to start a corrective action (boron dilution stop and/or emergency boron injection) to prevent the core from becoming critical. The maximum dilution rate is based on the abnormal condition of two centrifugal charging pumps delivering unborated makeup water to the Reactor Coolant System at a particular time during refueling when the boron concentration is at the maximum value and the water volume in the system is at a minimum.

At least two separate and independent flow paths are available for reactor coolant boration; i.e., the charging line, or the reactor coolant pumps labyrinth seals. The malfunction or failure of one component does not result in the inability to borate the Reactor Coolant System. An alternate flow path is also available for emergency boration of the reactor coolant. As backup to the boration system, the operator can align the refueling water storage tank outlet to the suction of the charging pumps.

Boration during operating to compensate for power changes will be indicated to the operator from a combination of two sources: (a) the control rod movement and (b) the flow indicator in the boric acid transfer pump discharge line. When the emergency boration path is used, three indications to the operator are available. The primary indication is a flow indicator in the emergency boration line. The charging line flow indicator will indicate boric acid flow since the charging pump suction is aligned to the boric acid transfer pump for this mode of operation. The change in boric acid tank level is another indication of boric acid injection.

On loss of seal injection water to the reactor coolant pump seals, seal water flow may be reestablished by manually rerouting the flow or starting a standby charging pump. During operation without seal injection flow, the thermal barrier cooler serves to remove heat from the reactor coolant flow that passes through the thermal barrier cooler, thereby controlling the No. 1 seal leak-off temperature. In the event seal water injection flow cannot be reestablished prior to the reactor coolant pump No. 1 seal leak-off flow temperatures exceeding the alarm setpoint, the plant will be tripped and the reactor coolant pump operation stopped. Process controls will be utilized to maintain adequate seal cooling after the affected RCP(s) are secured.

It can be concluded that proper consideration has been given to station safety in the design of the system.

Galvanic Corrosion

The only types of materials which are in contact with each other in borated water are stainless steels, Inconel, Stellite (or equivalent) valve materials and Zircaloy fuel element cladding. Those materials have been shown[(1)] to exhibit only an insignificant degree of galvanic corrosion when coupled to each other.

For example, the galvanic corrosion of Inconel versus 304 stainless steel resulting from high temperature tests (575°F) in lithiated, boric acid solution was found to be less than 20.9 mg/dm^2 for the test period of 9 days. Further galvanic corrosion would be trivial since the cell currents at the conclusion of the tests were approaching polarization. Zircaloy versus 304 stainless steel was shown to polarize at 180°F in lithiated, boric acid solution in less than 8 days with a total galvanic attack of 3.0 gm/dm^2. Stellite versus 304 stainless steel was polarized in 7 days at 575°F in lithiated boric acid solution. The total galvanic corrosion for this couple was 0.97 mg/dm^2.

As can be seen from the tests, the effects of galvanic corrosion are insignificant to systems containing borated water.

Tests and Inspections

Those portions of the CVCS associated with the ECCS will be subject to the same type of inspections required for those systems as outlined in Chapter 6. Special tests and inspections for the remainder of the CVCS are not required because the system is in daily operation. Routine maintenance can be performed on system components during refueling.

9.2.3.1 References For Section 9.2

1. Sammarone, D. G., "The Galvanic Behavior of Materials in Reactor Coolants," WCAP 1844, August 1961.