# SECTION 9

# AUXILIARY SYSTEMS

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The following figures are controlled drawings and can be viewed and printed from the applicable listed aperture card.

# 9.2 CHEMICAL AND VOLUME CONTROL SYSTEM

## 9.2.1 Design Bases

The chemical and volume control system (CVCS) is designed to perform the following functions:

a. Maintain the reactor coolant chemistry and purity within specifications.

b. Maintain the reactor coolant volume within programmed limits.

c. Provide a means of adding and removing boron to control reactor reactivity level changes.

d. Provide a storage location and makeup water source to compensate for reactor system volume changes during plant heat up and cooldown at the maximum allowed rate.

e. Provide a storage location and makeup water source to compensate for reactor system volume changes due to power level changes.

f. Provide a means to hydrostatically test the reactor coolant system.

g. Provide a means for hot leg injection in the post-LOCA long term cooling.

h. Provide a means for collecting and reusing reactor coolant pump mechanical seal controlled leakage.

i. Provide a system for mixing and storing concentrated boric acid solution for use in the reactor coolant system.

j. Provide a means for addition of chemicals to the reactor coolant system, e.g. pH control in the form of $Li_7OH$; oxygen control in the form of $N_2H_4$ when the plant is cold; hydrogen peroxide for forced oxygenation during some plant shutdowns.

k. Provide a means of controlling reactor system hydrogen concentration.

l. Provide auxiliary spray flow to the pressurizer.

For more supporting details of the Chemical and Volume Control System (CVCS) components, the Technical Specifications, the CQE Manual, the EEQ Manual, and the Regulatory Guide 1.97 Responses should be consulted.

### 9.2.1.1 Design Cyclic Loads

The following design cyclic transients, which include conservative estimates of the operational requirements for the components listed in Section 9.2.1.2, were used in the fatigue analysis required by the applicable design codes for certain components within the CVCS:

a) 500 reactor heatup and cooldown cycles, at a heating and cooling rate of 100°F/hr, during the system 40-year design life.

b) 500 reactor power change cycles over the range of 10 percent to 100 percent of full load with a ramp load change of 10 percent of full load per minute increasing or decreasing.

c) 500 reactor cycles of 10 percent of full load step power changes increasing from 10 percent to 90 percent of full power and decreasing from 100 percent to 20 percent of full power.

d) 10 cycles of hydrostatic testing the reactor coolant system at 3125 psia and at a temperature at least 60°F above the Nil Ductility Transition Temperature (NDTT) of the limiting reactor component.

e) 200 cycles of leak testing the reactor coolant system at 2100 psia and at a temperature at least 60°F greater than the NDTT of the reactor vessel.

f) 400 reactor trips when at 100 percent power.

g) 1000 cycles of Maximum Purification

h) 8000 cycles of Boron Dilution

In addition to the above list of normal design transients the following abnormal transients were also considered when arriving at a satisfactory usage factor:

i) 40 cycles of loss of turbine load with delayed reactor trip from 100 percent power.

j) 40 cycles of total loss of reactor coolant flow when at 100 percent power.

k) 5 cycles of loss of secondary system pressure.

l) 80 cycles of Low Volume Control Tank Level.

m) 500 cycles of Loss of Charging.

n) 700 cycles of Loss of Letdown.

o) 200 cycles of Long Term Letdown Isolation (in excess of 1 hour).

p) 700 cycles of Short Term Letdown Isolation (up to 1 hour).

q) 200 cycles of Intermittent Manual Charging (significant only for charging nozzles).

The number of cycles, defined for each transient above, are not design limits but rather engineering estimates as to the number of cycles that might be incurred over the assumed design life of the plant. The significance of these numbers is that the cumulative fatigue usage of all transients, as defined above, is no greater than 1.0 which is the design limit imposed by the applicable design codes. An assumed number of cycles for each transient is necessary to calculate a fatigue usage contribution for that transient. An increase in any one of the cycle number estimates, above, may necessitate a decrease in one or more of the others to satisfy the cumulative usage limit of 1.0. Although not design limits, the defined cycles are useful benchmarks against which to compare the actual incurred cycles which are required to be recorded by Technical Specification 5.10.2.f as implemented by SO-O-23. In the event that the incurred cycles are likely to or actually exceed these estimates, the supporting calculations may require revision to justify changes in these numbers.

### 9.2.1.2 Design Service Life Considerations

The major CVCS system components were designed for a 40-year service life (which is the basis for the licensed number of operating years for the plant). This number is not a design limit but rather an assumed engineering basis for estimating the number of cycles for transients which significantly contribute to the fatigue usage of the affected components. The design limit is that the cumulative fatigue usage, for all transients over the life of the plant, must be no greater than 1.0.

| CVCS Components Designed for Fatigue | Code Used for Fatigue Design |
|---|---|
| Charging Nozzles | ASME Section III |
| Regenerative Heat Exchanger | ASME Section III, Class A* |
| Letdown Heat Exchanger | ASME Section III, Class A* |
| Piping | USAS B31.7, Class 1 |

***NOTE**: The fatigue rules of Class A were conservatively applied even though the vessels were constructed as Class C which does not require fatigue analysis.

Thermal sleeves were used in the charging nozzles, regenerative heat exchanger tube side inlet, tube side outlet, shell side outlet and interconnecting pipe nozzles and letdown heat exchanger tube side inlet nozzle to minimize the fatigue usage, associated with fluid thermal transients. The thermal sleeves are not part of the code pressure boundary and are therefore not subject to the fatigue limitations imposed by the codes applicable to the nozzles. The design of the sleeves is such that their expected fatigue life is in excess of the assumed design life of the plant.

## 9.2.2 System Description

### 9.2.2.1 General

The chemical and volume control system is shown in the simplified block diagram, Figure 9.2-1, and the detailed piping and instrumentation diagrams, P&ID E23866-210-120 and E-23866-210-121. Coolant normally flows through the chemical and volume control system, as shown by the heavy lines in P&ID E23866-210-120 and E-23866-210-121. The letdown coolant from the cold leg of the reactor coolant system passes through the tube side of the regenerative heat exchanger and is partially cooled. The fluid pressure is reduced and the flow rate is regulated by the letdown control valves. The temperature is further reduced in the letdown heat exchanger to a level consistent with long ion exchanger resin life. The pressure in the system between the letdown control valves and the letdown heat exchanger is controlled by the letdown back pressure control valve to prevent flashing. The coolant then passes through an ion exchanger and a filter and is sprayed into the volume control tank. The charging pumps take suction from the volume control tank and return the coolant to the reactor coolant system by way of the shell side of the regenerative heat exchanger. The heat exchanger transfers heat from the letdown coolant to the charging coolant before the charging coolant is returned to the reactor coolant system.

If the valve control switches are selected to AUTO, and the level in the volume control tank reaches the high level setpoint, the letdown flow is automatically diverted to the waste disposal system. If the level in the volume control tank reaches the low-low level setpoint, makeup water from the safety injection and refueling water tank (SIRWT) is automatically supplied to the suction of the charging pumps.

With the level in the normal operating level band, the volume control tank has sufficient capacity to accommodate a full to zero power decrease without makeup system operation.

The boric acid concentration and chemistry of the coolant are maintained by the chemical and volume control system. Concentrated boric acid solution is prepared in a batching tank and is stored in two concentrated boric acid storage tanks. Two pumps are provided to transfer concentrated boric acid to the volume control tank or the charging pump suction. The piping is arranged such that the boric acid may be mixed with demineralized water in a predetermined ratio. The solution is introduced to the reactor coolant system by the charging pumps.

Chemicals are introduced to the reactor coolant system by means of the boric acid pump which removes the chemical solution from the concentrated boric acid tanks or by means of a metering pump which removes the chemical solution from a chemical addition tank and transfers it to the charging pump suction header.

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

Any substantial leakage in the reactor coolant system may be detected while the plant is at power by monitoring pressurizer level, volume control tank level, and charging and letdown rates.

The general performance parameters are given in Table 9.2-1.

Table 9.2-1 - "General Performance Parameters"

| | |
|---|---|
| Nominal Letdown Flow, gpm | 36 |
| Nominal Purification Flow Rate, gpm | 36 |
| Nominal Charging Flow, gpm | 40 |
| Reactor Coolant Pump Controlled Bleed-off (4 pumps), gpm | 4 |
| Maximum Letdown Temperature at Loop, °F | 547 |
| Nominal Charging Temperature at Loop, °F | 440 |
| Ion Exchanger Operating Temperature, °F | 120 |

### 9.2.2.2 Volume Control

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

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

The volume control tank coolant level may be automatically controlled, but is normally manually controlled by Operations using feed and/or bleed. When the level in the tank reaches the high-level setpoint, the letdown flow may be automatically diverted to the waste disposal system. If automatic operation is selected and the level in the tank reaches the low-level setpoint, a preset blend of concentrated boric acid and demineralized water can be introduced into the volume control tank. Should the level in the tank reach the low-low level setpoint, the system automatically closes the outlet valve on the tank and switches the suction of the charging pumps to the safety injection and refueling water tank (SIRWT).

The volume control tank can store enough coolant within its normal operating level to compensate for a full to zero power decrease in the reactor coolant volume without requiring makeup. The tank is supplied with hydrogen and nitrogen gas. Gases are vented to the waste gas vent header.

9.2.2.3 Chemical Control

The CVCS purifies and conditions the coolant by means of ion exchangers, filters, degasification and chemical additives. The purification ion exchangers contain a mixed bed resin which removes soluble nuclides by ion exchange and insoluble particles by the filter action of the resin beds.

A cation ion exchanger is provided for the removal of cesium and/or lithium from the coolant if required.

Cartridge-type filters located downstream of the ion exchangers retain resin fines and remove insoluble particles that may pass through the resin bed.

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

The reactor coolant is chemically conditioned to the typical conditions shown in Table 9.2-2 by:

a. Hydrazine scavenging to remove oxygen during startup;

b. Maintaining excess hydrogen concentration to control oxygen concentration during operation;

c. Chemical additives to control pH during operation.

d. Hydrogen peroxide for forced oxygenation during some plant shutdowns. The following restrictions apply to addition of hydrogen peroxide:

   1) On Shutdown Cooling, RCS temperature <180°F, Pressurizer liquid temperature <250°F.

   2) RCS hydrogen ≤5 cc/kg.

3) I-131 ≤0.025 μCi/gm.

4) Hydrogen peroxide used: ≤30%, unstabilized.

5) Hydrogen peroxide added via CVCS Chemical Addition Tank.

6) RCS hydrogen peroxide residual 2.5 to 10 ppm.

7) Bypass CVCS Ion Exchangers prior to addition.

The chemical addition tank and metering pump are used to feed chemicals to the charging pumps which inject the additives into the reactor coolant system. The concentration of hydrogen in the reactor coolant is controlled by maintaining a hydrogen overpressure in the volume control tank. Hydrogen gas is maintained in the volume control tank when lithium hydroxide is used for pH control.

The chemical and volume control system is designed to prevent the activity of the reactor coolant from exceeding approximately 235 μCi/cc with 1 percent failed fuel elements.

When adding hydrogen peroxide there is a possibility of an explosive environment being created in tanks that are connected to the RCS. Thus the procedure controlling addition of hydrogen peroxide requires sampling and analysis of the Quench Tank, VCT, Vent Header, in service Waste Gas Decay Tank and the Reactor Coolant Drain Tank for an explosive environment before and after the addition of hydrogen peroxide.

Table 9.2-2 - "Typical Reactor Coolant and Deaerated Primary Makeup Water Chemistry"

| | Reactor Coolant | Deaerated Primary Makeup Water |
|---|---|---|
| Specific Conductivity, Prior to Additives, micromhos/cm (maximum) | 40 | 2.0 |
| Nominal pH (77°F), range | 4.5 to 10.2 | 5.8 to 8.0 |
| Hydrogen (77°F), range, cc(STP)/Kg | 27-50 | - |
| Oxygen (77°F), maximum (ppm) | 0.1 | 0.1 |
| Halogens | | |
| Chlorides, ppm (maximum) | 0.15 | 0.15 |
| Fluorides, ppm (maximum) | 0.10 | 0.10 |
| LiOH, ppm | LiOH Program (Ref. 9.2-1) | - |
| Suspended Solids, maximum, ppm | 0.010 for Plant Modes 1 & 2 | |
| Boric Acid Concentration | | |
| Maximum (77°F), ppm | 15,000 | - |
| Nominal (77°F), ppm | 0 - 2,500 | - |

### 9.2.2.4 Reactivity Control

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

a. Optimize the position of the control element assemblies;

b. Compensate for reactivity changes caused by reactor coolant temperature variations, core burnup and xenon concentration variations;

c. Provide a margin of shutdown reactivity for maintenance, refueling or emergencies.

The system includes a batching tank for preparing the boric acid solution, two tanks for storing the solution, and two pumps for supplying boric acid solution to the makeup system.

Normally, the boric acid concentration of the coolant is adjusted by feed and bleed. To change concentration, the makeup (feed) system supplies either demineralized water or concentrated boric acid to the volume control tank and the letdown (bleed) stream is diverted to the waste disposal system. Toward the end of a core cycle, the quantities of waste produced due to feed and bleed operations becomes excessive and one of the two deborating ion exchangers is then used to reduce the boron concentration.

The system adds boric acid to the reactor coolant and thereby decreases reactivity at a sufficient rate to override the maximum increase in reactivity due to cooldown and the decay of xenon in the reactor.

The control element assemblies (CEAs) can decrease reactivity far more rapidly than the boron removal system can increase reactivity.

The charging pumps may be used to leak test the reactor coolant system at normal operating pressure when the plant is shutdown. Leaks in the reactor coolant system may be detected while the plant is at power by monitoring pressurizer level, volume control tank level, and charging and letdown rates.

## 9.2.3 System Components

The major components of the chemical and volume control system and their functions are described in this section.

### 9.2.3.1 Regenerative Heat Exchanger

The regenerative heat exchanger transfers heat from the letdown stream to the charging stream. Materials of construction were primarily austenitic stainless steel. The characteristics of the regenerative heat exchanger are given in Table 9.2-3.

Table 9.2-3 - "Regenerative Heat Exchanger"

| | |
|---|---|
| Item No. | CH-6 |
| Quantity | 1 |
| Type | Double Shell and Tube, Horizontal |
| Code | ASME III, Class C, 1968 |
| Tube Side (Letdown) | |
| Fluid | Reactor Coolant |
| Design Pressure, psig | 2485 |
| Design Temperature, °F | 650 |
| Materials | Austenitic Stainless Steel |
| Pressure Loss at 36 gpm, psi | 6 |
| Pressure Loss at 116 gpm, psi | 40 |
| Shell Side (Charging) | |
| Fluid | Reactor Coolant |
| Design Pressure, psig | 3025 |
| Design Temperature, °F | 650 |
| Materials | Austenitic Stainless Steel |
| Pressure Loss at 40 gpm, psi | 4 |
| Pressure Loss at 120 gpm, psi | 50 |

Operating Parameters

| Tube Side (Letdown) | Normal | Unbalanced Charging With Heat Transfer | Maximum Purification | Unbalanced Letdown |
|---|---|---|---|---|
| Flow, gpm | 36 | 26 | 116 | 116 |
| Inlet Temperature, °F | 547 | 547 | 547 | 547 |
| Outlet Temperature, °F | 207 | 167 | 375 | 421 |
| Shell Side (Charging) | | | | |
| Flow, gpm | 40 | 120 | 120 | 40 |
| Inlet Temperature, °F | 120 | 120 | 120 | 120 |
| Outlet Temperature, °F | 440 | 208 | 303 | 520 |
| Heat Transfer, Btu/hr | $6.48 \times 10^6$ | $5.19 \times 10^6$ | $15.30 \times 10^6$ | $8.26 \times 10^6$ |

The following explanation is presented to explain the reason for changing the classification of the regenerative heat exchanger from an ASME Section III, Class A, 1968 vessel (PSAR page IX-2-8) to an ASME Section III, Class C vessel in Table 9.2-3 above: The Fort Calhoun Station regenerative heat exchanger was originally required to be an ASME Section III, Class A vessel following a similar classification assigned to the Palisades regenerative heat exchanger. A Class A vessel was chosen because the vessel was carrying high temperature-high-pressure radioactive reactor coolant water. It was a part of the only path for injecting boric acid into the reactor coolant system, and this classification was suggested by then existing Code practice. Evaluation of design codes and system safety classification criteria placed emphasis on safety function and radioactivity release to the environment rather than fluid properties. Therefore, as detailed design progressed, the minimum design requirements for the regenerative heat exchanger were reduced from Class A to Class C. This reclassification of the regenerative heat exchanger conforms to the General Design Criteria requirement that safety related components be designed to quality standards that reflect the importance of their safety function. The unit is located inside the containment building and failure of either the shell or tube side will not result in uncontrolled radioactivity release to the environment, nor prevent safe shutdown of the reactor.

Several additional significant reasons which are considered sufficient justification for acceptance of this classification are as follows:

a. It is possible to isolate the RHX on both the shell and tube side with isolation valves which are remotely operable from the control room and by a manual valve which is outside the containment on the charging side.

b. Should it ever become necessary to completely isolate the RHX, an alternate charging path exists for charging water to the primary plant by utilizing the high pressure safety injection header.

c. Additional Quality Control and Fatigue Analysis requirements have been placed on the RHX, beyond those normally required of an ASME Section III, Class C vessel. These additional requirements are discussed below.

1. A fatigue analysis equivalent to the requirements of a Class A vessel was required of the manufacturer. The analysis has been reviewed under the direction of Licensed Professional Engineers at Combustion Engineering to assure the completeness and accuracy of the analysis.

2. The Quality Control requirements of Appendix IX to ASME Section III have been met. All inspections were performed in accordance with written procedures which had been reviewed by Combustion Engineering (CE) Quality Assurance (QA) personnel. Additionally, CE QA personnel witnessed certain predetermined inspections, and conducted random periodic surveillance inspections. Inspection records have been kept at the office of the manufacturer and also at CE. The certification of inspection compliance has been forwarded to the Omaha Public Power District.

3. Non-destructive testing was witnessed by CE QA personnel who were qualified to ASME Section III, Appendix IX procedures. All nondestructive testing procedures have been reviewed by CE QA personnel and were considered to be in accordance with Appendix IX of ASME Section III.

As a result of the plant design and additional fatigue analysis and QA requirements as discussed above, the present classification of the RHX is considered to be the proper quality design standard for use to satisfy the application of the RHX (Ref. 9.2-2) (Ref. 9.2-3).

### 9.2.3.2 Letdown Control Valves

The letdown control valves regulate the reactor coolant flow from the regenerative heat exchanger as required by the pressurizer level regulating system. In addition, the valves function to reduce the pressure of the letdown fluid to about 300 psig. The letdown flow is normally about 36 gpm, primarily for coolant purification, but increases or decreases as the pressurizer water level changes. The valves are air operated and fail closed. All parts in contact with reactor coolant are of austenitic stainless steel. The valve characteristics are given in Table 9.2-4 (Ref. 9.2-4).

Table 9.2-4 - "Letdown Control Valves"

| | |
|---|---|
| Item No's. | LCV-101-1 & 2 |
| Quantity | 2 |
| Design Pressure, psig | 2485 |
| Design Temperature, °F | 650 |
| Flow | |
| Maximum, gpm | 116 |
| Minimum, gpm | 26 |

### 9.2.3.3 Letdown Heat Exchanger

The letdown heat exchanger cools the letdown stream temperature from the outlet of the regenerative heat exchanger to a temperature suitable for long term operation of the purification system. Component cooling water system fluid is the cooling medium on the shell side of the letdown heat exchanger. Materials of construction are primarily austenitic stainless steel and carbon steel. The characteristics of the letdown heat exchanger are given in Table 9.2-5.

Table 9.2-5 - "Letdown Heat Exchanger"

| | |
|---|---|
| Item No. | CH-7 |
| Quantity | 1 |
| Type | Shell and Tube, Horizontal |
| Code | ASME III, Class C, 1968 |
| **Tube Side (Letdown)** | |
| Fluid | Reactor Coolant |
| Design Pressure, psig | 650 |
| Design Temperature, °F | 550 |
| Pressure Loss at 36 gpm, psi | 5.5 |
| Pressure Loss at 120 gpm, psi | 40 |
| Materials | Austenitic Stainless Steel |
| **Shell Side (Cooling Water)** | |
| Fluid | Component Cooling Water |
| Design Pressure, psig | 150 |
| Design Temperature, °F | 250 |
| Materials | Carbon Steel |
| Maximum Allowable Flow Rate, lb/hr | 600,000 |

Operating Parameters

| Tube Side (Letdown) | Normal | Maximum Unbalanced Charging | Maximum Maximum Purification | Maximum Unbalanced Letdown |
|---|---|---|---|---|
| Flow, gpm | 36 | 26 | 116 | 116 |
| Inlet Temperature, °F | 207 | 167 | 375 | 421 |
| Outlet Temperature, °F | 120 | 120 | 120 | 120 |
| Heat Transfer, Btu/hr | $1.54 \times 10^6$ | $0.59 \times 10^6$ | $14.6 \times 10^6$ | $17.5 \times 10^6$ |
| **Shell Side (Cooling Water)** | | | | |
| Flow, gpm | 36 | 11 | 800 | 1010 |
| Inlet Temperature, °F | 90 | 50 | 90 | 90 |
| Outlet Temperature, °F | 177 | 157 | 127 | 125 |

### 9.2.3.4 Ion Exchangers

Two mixed bed purification ion exchangers purify the reactor coolant by removing corrosion and fission products. The anion resin is initially in the hydroxyl form and is converted to the borated form. Each unit was designed to handle the maximum letdown flow of 116 gpm. The vessels and retention screens are of austenitic stainless steel construction.

The two deborating ion exchangers are used to remove boron from the reactor coolant when this mode of operation is preferable to a feed and bleed operation. Other than being taller, the units are identical in construction to the purification ion exchangers. The anion resin is initially in the hydroxyl form and is converted to a borated form during boron removal. Each unit is designed for the maximum letdown flow of 116 gpm, and the quantity of resin in each is sufficient to remove the equivalent of 50 ppm of boron from the entire reactor coolant system. The vessels and retention screens are of austenitic stainless steel construction.

The cation ion exchanger is identical in construction to the purification ion exchangers. The unit is charged with a cation resin and is provided for the removal of lithium and cesium fission products from the coolant if required. The unit is designed to handle the maximum letdown flow of 116 gpm.

The characteristics of the ion exchangers are given in Table 9.2-6.

Table 9.2-6 - "Ion Exchangers"

| | |
|---|---|
| Item No's. | CH-8A, 8B, 9A, 9B & 10 Quantity 5 |
| Type | Flushable |
| Design Pressure, psig | 200 |
| Design Temperature, °F | 250 |
| Nominal Operating Pressure, psig | 25 |
| Nominal Operating Temperature, °F | 120 |
| Resin Volume (usable), $ft^3$ | 22 |
| Nominal Flow Rate, gpm | 36 |
| Design Maximum Flow Rate, gpm | 116 |
| Retention Screen Rating | 0.007" x 0.007" opening |
| Code for Vessel | ASME III, Class C, 1968 |
| Material | Austenitic Stainless Steel |
| Fluid | 6.25 wt % Boric Acid, Maximum |

9.2.3.5 Purification Filters

The purification filters collect resin fines and insoluble particulates from the reactor coolant. Each filter can accommodate the maximum letdown flow of 116 gpm. The filter housings are austenitic stainless steel. The characteristics of the filters are given in Table 9.2-7.

Table 9.2-7 - "Purification Filters"

| | |
|---|---|
| Item No's. | CH-17A & 17B |
| Quantity | 2 |
| Design Pressure, psig | 200 |
| Design Temperature, °F | 250 |
| Design Flow, gpm | 116 |
| Nominal Flow, gpm | 36 |
| Maximum Flow, gpm | 160 |
| Code for Vessel | ASME III, Class C, 1968 |
| Material | Austenitic Stainless Steel |
| Fluid | 6.25 wt % Boric Acid, Maximum |

9.2.3.6 Volume Control Tank

The volume control tank accumulates water from the reactor coolant system. The tank has sufficient capacity within the normal operating level band to allow a full power to zero power decrease without makeup system operation. The tank provides a gas space where a partial pressure of hydrogen is maintained to control the hydrogen concentration in the reactor coolant. A vent to the waste gas vent header permits removal of hydrogen, nitrogen and gaseous fission products released from solution in the volume control tank. The tank is of austenitic stainless steel construction and provided with overpressure protection. Level controls divert coolant to the waste disposal system on high level or can cause a preset blend of concentrated boric acid and demineralized water to be introduced into the tank. However, makeup to the volume control tank is usually controlled manually. The characteristics of the tank are given in Table 9.2-8.

Table 9.2-8 - "Volume Control Tank"

| | |
|---|---|
| Item No. | CH-14 |
| Quantity | 1 |
| Type | Vertical, Cylindrical |
| Design Pressure, Internal, psig | 75 |
| Design Pressure, External, psig | 15 |
| Design Temperature, °F | 250 |
| Total Internal Volume, $ft^3$ | 386 |
| Operating Pressure Range, psig | 0 to 65 |
| Nominal Operating Pressure, psig | 20 to 35 |
| Nominal Operating Temperature, °F | 120 |
| Nominal Spray Flow (letdown), gpm | 36 |
| Blanket Gas | Hydrogen and/or Nitrogen |
| Code | ASME III, Class C, 1968 |
| Fluid | 2-1/2 to 4-1/2 wt% Boric Acid, Maximum |
| Material | Austenitic Stainless Steel |

#### 9.2.3.7 Charging Pumps

Three charging pumps are provided to return the purification flow to the reactor coolant system during plant steady state operations. As a result of a Pressurizer Pressure Low Signal (PPLS) or Containment Pressure High Signal (CPHS), all three pumps are started and discharge concentrated boric acid into the reactor coolant system. The pumps are of the positive displacement type. All pressure containing portions of the pump are austenitic stainless steel with internal materials selected for compatibility with boric acid and optimum performance. The charging pumps have a design flow rate of 40 gpm each. The characteristics of the pump are given in Table 9.2-9.

Although the three charging pumps start upon receipt of an Engineered Safeguards signal, no credit is taken for charging pump operation in the USAR Section 14 safety analyses and as such these pumps are not classified as Engineered Safeguards equipment. When the USAR Section 14 safety analyses are more limiting with operation of these pumps, they are assumed to operate.

Table 9.2-9 - "Charging Pumps"

| | |
|---|---|
| Item No's. | CH-1A, 1B and 1C |
| Quantity | 3 |
| Type | Positive Displacement |
| Design Pressure, psig | 2735 |
| Design Temperature, °F | 250 |
| Flow Rate, gpm | 40 |
| Nominal Discharge Pressure, psig | 2285 |
| Nominal Suction Pressure, psig | 50 |
| Nominal Temperature of Pumped Fluid, °F | 120 |
| Maximum Discharge Pressure (short term), psig | 3010 |
| NPSH Required, psia | 7.5 |
| Maximum Pressure Pump Starts Against, psia | 2500 |
| Driver Rating, HP | 75 |
| Temperature Rise (maximum), °F | 15 |
| Materials In Contact with Pumped Fluid | Stainless Steel or Equivalent Corrosion Resistance |
| Fluid | 2-1/2 to 4-1/2 wt % Boric Acid, Maximum |

### 9.2.3.8 Chemical Addition Tank

The chemical addition tank provides a reservoir for the metering pump. The tank is austenitic stainless steel. The characteristics of the tank and the strainer are given in Table 9.2-10.

Table 9.2-10 - "Chemical Addition Tank and Strainer"

| | |
|---|---|
| Tank, Item No. CH-15 | |
| Quantity | 1 |
| Capacity, $ft^3$ | 1.3 |
| Design Pressure | Atmospheric |
| Nominal Operating Temperature | Ambient |
| Material | Austenitic Stainless Steel |
| Fluid | Hydrazine ($N_2H_4$); LiOH<br>Hydrogen Peroxide<br>($H_20_2$ 30% or less) |
| Strainer, Item No. CH-23 | |
| Quantity | 1 |
| Type | Basket |
| Design Pressure, psig | 100 |
| Design Temperature, °F | 250 |
| Screen Size, US Mesh | 60 |
| Design Flow, gph | 40 |
| Material | Austenitic Stainless Steel |
| Fluid | Hydrazine ($N_2H_4$); LiOH<br>Hydrogen Peroxide<br>($H_20_2$ 30% or less) |

### 9.2.3.9 Metering Pump

The metering pump is a positive displacement pump constructed of austenitic stainless steel with internals selected for compatibility with various chemicals handled. The pump provides accurately controlled injection of chemicals from the chemical addition tank to the charging pump suction header. The pump characteristics are given in Table 9.2-11.

Table 9.2-11 - "Metering Pump"

| | |
|---|---|
| Item No. | CH-3 |
| Quantity | 1 |
| Type | Positive Displacement, Variable Capacity |
| Design Pressure, psig | 150 |
| Design Temperature, °F | 200 |
| Design Flow Rate, gph | 40 |
| Design Discharge Pressure (internal relief valve setpoint), psig | 100 |
| Nominal Fluid Temperature, °F | Ambient |
| Horsepower | ¼ |
| Materials | Austenitic Stainless Steel |
| Fluids | Hydrazine ($N_2H_4$); LiOH; Hydrogen Peroxide ($H_20_2$ 30% or less) |

### 9.2.3.10 Concentrated Boric Acid Storage Tanks

Each of the two concentrated boric acid tanks stores enough concentrated boric acid solution below the normal makeup level band to bring the reactor to a cold shutdown condition at any time during the core lifetime. The solution is prepared in the boric acid batching tank and flows through the boric acid strainer before entering the storage tanks. The combined capacity of the tanks is also sufficient to bring the coolant to refueling concentration before initiation of a cooldown for refueling. The tanks are constructed of austenitic stainless steel. The characteristics of the batching tank, boric acid strainer and the boric acid storage tanks are given in Table 9.2-12.

Table 9.2-12 - "Concentrated Boric Acid Preparation and Storage"

Concentrated Boric Acid Storage Tanks, Item No's. CH-11A & 11B

| | |
|---|---|
| Quantity | 2 |
| Internal Volume, $ft^3$ | 773 |
| Design Pressure (internal), psig | 15 |
| Design Temperature, °F | 200 |
| Type Heaters | Duplicate Electrical Heat Tracing |
| Fluid, wt % Boric Acid Maximum | 2-1/2 to 4-1/2 |
| Material | Stainless Steel |
| Code | ASME III, Class C, 1968 |

Boric Acid Strainer, Item No. CH-21

| | |
|---|---|
| Quantity | 1 |
| Type | Basket |
| Design Pressure, psig | 150 |
| Design Temperature, °F | 200 |
| Screen Size, US Mesh | 60 |
| Design Flow, gpm | 50 |
| Materials | Stainless Steel |
| Fluid | 2-1/2 to 4-1/2 wt % Boric Acid |

Boric Acid Batching Tank, Item No. CH-12

| | |
|---|---|
| Quantity | 1 |
| Useful Volume, $ft^3$ | 67 |
| Design Pressure | Atmospheric |
| Design Temperature, °F | 200 |
| Nominal Operating Temperature, °F | 150 |
| Type Heater | Electrical Immersion |
| Heater Capacity, nomial, kW | 36 |
| Fluid | 2-1/2 to 4-1/2 wt % Boric Acid |
| Material | Austenitic Stainless Steel |

### 9.2.3.11 Boric Acid Pumps

The two boric acid pumps supply concentrated boric acid solution to the volume control tank or charging pump suction header, where the boric acid may be diluted with demineralized water. On receipt of the SIAS, these pumps line up with the charging pumps to permit direct introduction of concentrated boric acid into the reactor coolant system. Although the boric acid and charging pumps operate upon receipt of an Engineered Safeguards signal no credit is taken for their operation in the USAR Section 14 safety analyses. Each is capable of supplying boric acid at the maximum demand conditions. Wetted portions of the pumps are austenitic stainless steel with pump internals selected for suitability for the service. The pump and filter characteristics are given in Table 9.2-13.

Table 9.2-13 - "Boric Acid Pumps and Filter"

Pumps, Item No's. CH-4A & 4B

| | |
|---|---|
| Quantity | 2 |
| Type | Centrifugal |
| Design Pressure, psig | 150 |
| Design Temperature, °F | 250 |
| Design Head (100 psig), ft | 230 |
| Design Flow, gpm | 143 |
| NPSH Required, ft | 20 |
| Horsepower | 30 |
| Fluid | 2-1/2 to 4-1/2 wt % Boric Acid |
| Material in Contact With Liquid | Stainless Steel |

Filter, Item No. CH-18 (normally bypassed)

| | |
|---|---|
| Quantity | 1 |
| Type Elements | Synthetic Fiber |
| Retention of 5 Micron Particles, % | 98 |
| Design Pressure, psig | 150 |
| Design Temperature, °F | 250 |
| Design Flow, gpm | 120 |
| Materials | Austenitic Stainless Steel |
| Liquid | 2-1/2 to 4-1/2 wt % Boric Acid |
| Code | ASME III, Class C, 1968 |

## 9.2.4 System Operation

### 9.2.4.1 Startup

During startup, the plant is brought from cold shutdown to hot standby at normal operating pressure and zero power temperature. During the heatup and after the steam bubble is established, the operator adjusts the pressurizer water level manually with the letdown control valves. The level controls of the volume control tank may automatically divert the letdown flow to the radioactive waste disposal system (RWDS).

If the residual activity in the core is insufficient to reduce the oxygen in the reactor coolant by recombining it with excess hydrogen during heatup, hydrazine may be used to scavenge the oxygen at a coolant temperature below 250°F. If required, chemicals are added to control the pH of the coolant.

The volume control tank is initially vented to the RWDS. After the tank is purged with nitrogen the vent is secured, and a nitrogen and hydrogen atmosphere is established.

Throughout startup, one purification ion exchanger and filter are in service to reduce the activity of the RCS.

While maintaining the required shutdown margin, the boric acid concentration may be reduced during heatup. The operator may inject a predetermined amount of demineralized makeup water by operating the system in the 'Dilute' mode. However, the shutdown CEA groups must be fully withdrawn from the core prior to performing a 'dilution to criticality'. The concentration of boric acid in the reactor coolant is determined by sample analysis.

### 9.2.4.2 Normal Operation

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

During normal operation:

a. Level instrumentation on the pressurizer automatically controls the volume of water in the reactor coolant system by automatic control of the letdown flow rate and by varying the number of operating charging pumps and pressurizer heaters;

b. Operators control VCT level and boric acid concentration in the RCS by adding concentrated boric acid solution and/or water to the VCT and/or diverting letdown to the RWDS;

c. Instrumentation on the volume control tank may automatically control the level of water in the tank as described in Section 9.2.2. However, this is normally done manually;

d. The hydrogen-nitrogen concentration and pH of the coolant are controlled as described in Section 9.2.2;

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

   1. In the "Dilute" mode, a quantity of demineralized makeup water is selected and introduced into the charging pump suction at a preset rate. When the integrating flowmeter indicates that the selected quantity of makeup water has been added, the flow is automatically terminated;

2. In the "Borate" mode, a quantity of concentrated boric acid is selected and introduced at a preset rate as described above;

3. In the "Manual Blend" mode, the flow rate of the demineralized water and concentrated boric acid are set for any blend concentration between demineralized makeup water and concentrated boric acid;

4. In the "Automatic" mode, the flow rates of the demineralized water and concentrated boric acid are set to achieve the concentration present in the reactor coolant. The solution is automatically blended and introduced into the volume control tank according to signals received from the volume control tank level program. This mode of operation is not normally used.

f. The letdown flow is routed through one of the purification ion exchangers to reduce coolant activity resulting from soluble and insoluble corrosion and fission products. The coolant leaving the purification ion exchanger may be routed through the cation ion exchanger for lithium and cesium removal if necessary.

9.2.4.3 Cooldown

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

Before the plant is cooled down, the volume control tank is vented to the RWDS to reduce the activity and the nitrogen-hydrogen concentration in the reactor coolant system. The operator may also increase the letdown flow rate to accelerate degasification, ion exchange and filtration of the reactor coolant. The reactor is shutdown by inserting all the control rods in the reverse order used for startup. Then the operator increases the concentration of boric acid in the reactor coolant to the value required for cold shutdown and verified by chemical analysis prior to commencing plant cooldown. This is done to ensure that the reactor has an adequate shutdown margin throughout its period of cooldown.

During cooldown, the operator uses the letdown control valves and/or the charging pumps to adjust and maintain the level of water in the pressurizer. Makeup water is introduced at the shutdown boric acid concentration. The operator may switch the suction of the charging pumps to the safety injection and refueling water tank (SIRWT). The charging flow may be used as an auxiliary spray to cool the pressurizer when less than three reactor coolant pumps are in operation. This is required because minimal RCP spray flow is available with less than three RCPs in operation.

#### 9.2.4.4 Hot Leg Injection

Long term response to a large break Loss of Coolant Accident (LOCA) requires that, in order to prevent boron precipitation in the core, simultaneous hot and cold leg injection must be initiated. The CVCS system provides a path for hot leg injection in post-LOCA long term cooling. (Ref. 9.2-5).

### 9.2.5 Design Evaluation

Under emergency conditions, the charging pumps are used to inject concentrated boric acid into the reactor coolant system. Either PPLS, CPHS or pressurizer level control automatically starts all charging pumps. Because this function is not credited in the USAR Section 14 safety analyses these pumps are not considered Engineered Safeguards equipment. The SIAS also transfers the charging pump suction from the volume control tank to the discharge of the boric acid pump. If the boric acid pumps are not operable, boric acid flows by gravity from the concentrated boric acid tank to the charging pump suction header. If the charging line inside the reactor containment building is inoperative, the line may be isolated outside of the reactor containment and concentrated boric acid solution may be injected by the charging pumps through the safety injection system. Containment integrity is maintained during post LOCA situations by maintaining a higher pressure in the charging line than the containment atmospheric pressure.

A CIAS terminates letdown flow by closing two containment isolation valves. During an uncontrolled heat extraction event, the CIAS to the letdown flow isolation valves may be manually overridden (Ref. 9.2-13) for up to one hour in order to reduce excessive RCS inventory. In this situation, it is required that HPSI stop and throttle criteria (as defined in Emergency Operating Procedures) be met prior to overriding CIAS. This use of the letdown system is not credited in the Section 14 safety analyses.

### 9.2.6 Availability and Reliability

To assure reliability, the design of the CVCS incorporates redundant critical components. This reduces dependence on any single critical component. Redundancy is provided as follows:

| Component | Redundancy |
|---|---|
| Purification Demineralizer | Parallel Standby Unit |
| Purification Filters | Parallel Standby Unit |
| Deborating Ion Exchanger | Parallel Standby Unit |
| Charging Pump | Two Parallel Standby Units |
| Letdown Flow Control Valve | Parallel Standby Valve |
| Boric Acid Pump and Tank | Parallel Standby Unit |

The charging and boric acid pumps may be powered by the diesel-generators if normal power sources are lost. One charging pump and one boric acid pump are connected to each diesel-generator. The third charging pump may be fed from either emergency diesel (see Section 8). Physical separation and barriers are provided between the power and control circuits for the redundant pumps. Standby features are provided so that at least one charging pump operates after the PPLS and/or CPHS. If both diesels are available, both boric acid pumps operate. The charging pumps and boric acid pumps may be controlled locally at their switchgear. Separate power supplies and control circuits for the pumps assure that the system satisfies the single failure criterion. In the event of a fire in the cable spreading room or control room, one charging pump can be started from alternate shutdown panel AI-185.

When fuel is in the reactor and the reactor is subcritical there shall be at least one flow path to the core for boric acid injection. This flow path may be from the SIRWT, with at least 10,000 gals. available at refueling boron concentration or from a BAST which meets the requirements of Figure 9.2-3 for a SIRWT boron concentration at the technical specification limit.

The minimum volume of borated water contained in the concentrated boric acid tank(s) is dependent on the boric acid storage tank (BAST) and SIRWT boron concentrations. The minimum required volume curve is shown in Figure 9.2-3. Depending on the flow paths available, this volume of borated water can be either the combined volume of the two BASTs, or the minimum in each BAST, or can be contained in a specific BAST. The ambient temperature of the boric acid tank solution CH-11A and CH-11B shall meet the temperature requirements of Figure 9.2-4.

Each concentrated boric acid tank containing 2.5-4.5 weight percent boric acid has sufficient boron to bring the plant to a cold shutdown condition. Boric acid pumps are each of sufficient capacity to feed all three charging pumps at their maximum capacity.

The concentrated boric acid storage tank is sized for 2.5-4.5 weight percent boric acid solution and is capable of storing solution up to 4.5 weight percent solution. All components of the system are capable of maintaining 4.5 weight percent solution. The elevation of the concentrated boric acid tank is sufficiently above the charging pump suction so as to provide adequate gravity flow to the charging pumps. Figure 9.2-4 contains a 10°F bias to account for temperature measurement uncertainty.

The boric acid solution is stored in insulated tanks and is piped in insulated lines to preclude precipitation of the boric acid. If the boric acid pumps are not available, boric acid from the concentrated boric acid tanks may be gravity fed into the charging pump suction. If the charging line inside the reactor containment building is inoperative, the charging pump discharge may be routed via the safety injection system to inject concentrated boric acid into the reactor coolant system.

The piping systems and equipment which are of safety significance are defined on P&ID E-23866-210-120 and E-23866-210-121.

Analyses of pressure pulses in the charging line have been made to provide a basis for the design and installation of accumulators at the charging pump suctions and discharges. These accumulators restrain dynamic loadings on the piping to design limits. (Ref. 9.2-6).

The inputs to the analyses were pressures as a function of time at the pump suction and discharge. The procedures developed by the accumulator manufacturer were then used to obtain the proper size and precharge pressure for the accumulators and the resulting, reduced pressure pulses in the piping system.

## 9.2.7 Tests and Inspections

All equipment was subject to the test and inspection requirements of the applicable codes. System operation was demonstrated during the preoperational test program.

## 9.2.8 Specific References

9.2-1 PWR Primary Water Chemistry Guidelines, Electric Power Research Institute, R. A. Shaw, Report Number NP-4762-SR

9.2-2 CE Letter, CE-750-2091, Revision of AEC-Fort Calhoun Station Question 9.9, April 26, 1971, WIP Number 005322.

9.2-3 CE Letter, CE-750-1127, Regenerative Heat Exchanger Code Classification, May 29, 1969, WIP Number 005211.

9.2-4 Engineering Specification for Pneumatic Operated Control Valves, Specification Number 23866-220-704, June 27, 1968, WIP Number 070321.

9.2-5 NRC Safety Evaluation Report Related to the Effect of HPSI Header Cross Connect Valves on Hot Leg Injection, January 10, 1989.

9.2-6 SGA Pulsation Analysis Study, Project 04-4044-035, December 26, 1974, WIP Number 007839.

9.2-7 Specification 23886-220-302, "Engineering Specification for a Shell and Tube Heat Exchanger," (Regenerative Heat Exchanger, Reference USAR Section 9.2.1.2).

9.2-8 Specification 23886-220-303, "Engineering Specification for a Shell and Tube Heat Exchanger," (Letdown Heat Exchanger, Reference USAR Section 9.2.1.2).

9.2-9 Specification 750S-2305, "Engineering Specification for Primary Coolant Pipe and Fittings for Omaha Public Power District Fort Calhoun Station," (Charging Nozzles, Reference USAR Section 9.2.1.2).

9.2-10 ABB/CE Calculation O-PENG-CALC-009, Revision 00 (Regenerative Heat Exchanger, Reference USAR Section 9.2.1.2).

9.2-11 ABB/CE Calculation O-PENG-CALC-010, Revision 00 (Charging Nozzle, Reference USAR Section 9.2.1.2).

9.2-12 ABB/CE Letter O-PENG-99-004, (Letdown Heat Exchanger, Reference USAR Section 9.2.1.2).

9.2-13 NRC Safety Evaluation Report related to Amendment 191 concerning an Unreviewed Safety Question (USQ) on overriding the containment isolation actuation signal closure signal, July 22, 1999.

9.2-14 ABB/CE Nuclear Steam Supply System Chemistry Manual, CENPD-28, Revision 4.

9.2-15 ABB/CE Letter F-PENG-006, L-PENG-004, dated October 3, 1997, Response to Questions Regarding Hydrogen Peroxide Injection at St. Lucie

9.2-16 Florida Power and Light Inter-Office Correspondence ENG-SPSL-98-0567, dated October 16, 1998 (Addition of Hydrogen Peroxide to the RCS during Shutdown Cooling at St. Lucie, Units 1 and 2.

## 9.2.9 General References

9.2.9.1 Combustion Engineering CVCS System Description, CE-750-1331, September 9, 1969, WIP Number 018040, Revision 0.

9.2.9.2 NRC Safety Evaluation Report Related to Amendment Number 131 to Facility Operating License No. DPR-40, May 18, 1990.

9.2.9.3 NRC Safety Evaluation Report Related to Amendment 172 to Facility Operating License No. DPR-40, December 12, 1995.

# 9.4 AUXILIARY FEEDWATER SYSTEM

The Auxiliary Feedwater System (AFW) is designed to supply feedwater to the steam generators whenever the reactor coolant temperature is above 300°F and the main feedwater system is not in operation, e.g., during startup, cooldown or emergency conditions resulting in a loss of main feedwater. One portion of the system is a safety-grade, Seismic Category I, redundant system with Class 1E electric components. This portion meets the additional requirements of Items II.E.1.1 and II.E.1.2 of NUREG-0737. The other portion of the system added to increase overall system reliability is non safety grade, non Seismic and includes non Class 1E electrical components.

The safety class portion of the auxiliary feedwater system is an engineered safety features system, and hence, is part of the plant's engineered safeguards, as defined in Section 6. For more supporting details of components the Technical Specifications, the CQE Manual, the EEQ Manual, and the Regulatory Guide 1.97 Responses should be consulted.

## 9.4.1 Design Bases

The Auxiliary Feedwater System has the following design bases:

a. System flow rate and head requirements, (see Table 9.4-1).

b. Sufficient storage capacity to provide for the removal of heat produced from the stored energy above the isothermal condition corresponding to peak steam generator pressures and the maximum decay heat produced during the eight hours after a reactor trip assuming a power level of 102%. The minimum storage capacity of 55,000 gallons of water, approximately 11.4 feet on the Emergency Feedwater Storage Tanks (EFWST) level indicator, shall be maintained whenever the Reactor Coolant temperature is greater than 300°F. Alternate sources of additional water are available through operator action.

c. Seismic Class I design with the exception of the parts of the system located in the Turbine Building (see Appendix F).

d. Two safety class auxiliary feed pumps, each capable of meeting system requirements and with diverse power sources; one electric motor driven and the other steam turbine driven.

One non safety grade auxiliary feedwater pump capable of meeting system requirements with a diverse power source: diesel engine: diverse water supply: the condensate storage tank: and diverse location: basement level of the turbine building.

e. Auxiliary feedwater from the EFWST high in quality as controlled by plant procedures.

f. Two independent means of introducing feedwater into each steam generator; one from the main feedwater system, the other from the auxiliary feedwater system.

g. Availability of auxiliary feedwater at the intact steam generator(s) based on Auxiliary Feedwater System Actuation Logic (see Section 7.3.2.8). The non safety class AFW pump must be started by operator action.

h. Safety grade automatic start AFW signals and associated circuitry for the safety class portion of the system.

i. Automatic initiation of auxiliary feedwater system flow for the safety class portion of the system.

j. Automatic sequencing of the motor driven AFW pump to the emergency diesel bus upon loss of A.C. power.

k. Parallel supply valves for the water supply from the emergency feedwater storage tank to the AFW pumps suction.

l. Capability for delivery of feedwater to a minimum of one steam generator through a path which is nuclear safety grade, although alternate paths of delivery, non-safety grade, are incorporated in the design.

Table 9.4-1 - "Auxiliary Feedwater System Flow and Head Requirements"

| Case | Flow (gpm) | Steam Generator Pressure (psia) | Remarks |
|---|---|---|---|
| Hot Standby | 200 | 900 | Assume main feed pumps used 1st hour |
| Normal Cooldown | 300 | 900 | One reactor coolant pump on each reactor coolant loop operating |
| Loss of Feedwater | 180 | 1056 | Automatic actuation of safety grade portion on low SG level |
| Steam Line Break | 200 | 1000 | Motor driven pump only |

## 9.4.2 System Description

The auxiliary feedwater system is shown in P&ID 11405-M-252, 11405-M-253 and 11405-M-254. The components which comprise the Safety Class 3 portion of the system are isolatable from the non-safety portions of the condensate, feedwater, and steam systems. The system is considered to be that equipment required to store water required for the design heat removal and to feed it to the steam generators if the main feedwater pumps are not available. The auxiliary feedwater system is comprised of the equipment listed in Table 9.4-2, interconnecting piping and auxiliary feedwater piping to the steam generators.

Table 9.4-2 - "Auxiliary Feedwater System Equipment"

| Components and Item No's. | Equipment |
|---|---|
| **Pumps and Storage Tank (Safety Class)** | |
| FW-6 | Motor Driven Auxiliary Feed Pump |
| FW-10 | Turbine Driven Auxiliary Feed Pump |
| FW-19 | Emergency Feedwater Storage Tank |
| **Pumps and Storage Tank (Non Safety Class)** | |
| FW-54 | Diesel Engine Driven Auxiliary Feedwater Pump |
| DW-48 | Condensate Storage Tank |
| **Remotely Operated Valves** | |
| FCV-1368 | Motor Driven Auxiliary Feed Pump Recirculation Valve |
| FCV-1369 | Turbine Driven Auxiliary Feed Pump Recirculation Valve |
| HCV-1384 | Header Cross-Connect Valve |
| HCV-1107A | Steam Generator RC-2A Auxiliary Feed Containment Isolation Valve |
| HCV-1107B | Steam Generator RC-2A Auxiliary Feed Flow Control and Backup Containment Isolation Valve |
| HCV-1108A | Steam Generator RC-2B Auxiliary Feed Containment Isolation Valve |
| HCV-1108B | Steam Generator RC-2B Auxiliary Feed Flow Control and Backup Containment Isolation Valve |
| YCV-1045 | Turbine Driven Auxiliary Feed Pump Steam Stop Valve |
| YCV-1045A | Steam from Steam Generator RC-2A to FW-10 |
| YCV-1045B | Steam from Steam Generator RC-2B to FW-10 |
| **Instrument Channels** | |
| LT-1188 | Emergency Feedwater Storage Tank Level |
| FT-1368 | Motor Driven Auxiliary Feed Pump Suction Flow |
| FT-1369 | Turbine Driven Auxiliary Feed Pump Suction Flow |
| TE-1187 | Emergency Feedwater Storage Tank Temperature |
| FT-1109 | Steam Generator RC-2A Auxiliary Feedwater Flow |
| FT-1110 | Steam Generator RC-2B Auxiliary Feedwater Flow |
| LT-1183 | Emergency Feedwater Storage Tank Level |
| LT-911A/B/C/D | Level Transmitters Steam Generator RC-2A |
| PT-913A/B/C/D | Pressure Transmitters Steam Generator RC-2A |
| LT-912A/B/C/D | Level Transmitters Steam Generator RC-2B |
| PT-914A/B/C/D | Pressure Transmitters Steam Generator RC-2B |

| Components and Item No's. | Equipment |
|---|---|
| **Instrument Channels** | |
| FI-1112 | Diesel Driven Auxiliary Feedwater Pump Suction Flow (Non Safety Class) |
| LS-2120 | Diesel Driven Auxiliary Feedwater Pump, Fuel Oil Day Tank FO-38 Level Switch (Non-Safety Class) |
| **Other Instrumentation** | |
| TI-1382<br>TI-1383 | Temperature Indicators on surface of AFW pipe to detect possible check valve leakage that might cause steam binding of AFW pumps. |

### 9.4.3 System Components

The emergency feedwater storage tank is located in the Seismic Category I auxiliary building adjacent to the turbine room on the 1036 foot level. It is a horizontal carbon steel tank, 13.5 feet in diameter and 60 feet long. The design pressure is 50 psig. The tank is constructed according to the ASME Boiler and Pressure Vessel Code, Section VIII and is a seismic Category I design. The usable capacity of the tank is 57,500 gallons. It can be filled with water from the condensate pump discharge, the demineralized water header, the diesel driven auxiliary feedwater pump discharge or, in the case of an emergency, the raw water system and is maintained at or above the Technical Specification minimum volume and ready for operation.

Two safety class and one non-safety class auxiliary feed pumps are provided. One safety class pump is electric motor driven and the other is steam turbine driven. Both safety class pumps are located in the auxiliary building basement on the east side on the 989 foot level. The motor driven auxiliary feed pump is an eight stage centrifugal pump driven by a directly connected electric motor. The turbine driven auxiliary feed pump is a two stage centrifugal pump directly driven by a single stage, velocity compound turbine. The lube oil pump of this machine initially draws power from the instrumentation electrical supply until the turbine starts up and automatically transfers to the shaft driven oil pump. The oil cooling system is completely self-contained. The non safety grade auxiliary feedwater pump is driven by a diesel engine and is located in the southeast corner of the turbine building on the 990 foot level. The pump is an eight stage centrifugal pump driven through a speed increaser. The engine is capable of starting and running without reliance on external mechanical or electrical support systems. Cooling for the engine and speed increaser is provided from a first stage takeoff connection on the pump. Electrical power is provided by an engine mounted auxiliary generator and batteries. The diesel engine (FW-56) for the diesel driven pump, has a fuel oil transfer pump (FO-37) which can be powered by the engine driven generator. The pump transfers fuel oil from the auxiliary boiler under ground storage tank (FO-10) to a nominal 160 gallon fuel oil day tank (FO-38). The level in the fuel oil day tank can be maintained by automatic operation of the fuel oil transfer pump in response to low and high level signals (LS-2120). A minimum of 8,000 gallons of fuel oil is required to be maintained in the auxiliary boiler underground storage tank in accordance with Technical Specification 2.7. The feed pump data are shown in Table 9.4-3.

Table 9.4-3 - "Auxiliary Feed Pump Data"

| | Motor Driven Auxiliary Feed Pump | Turbine Driven Auxiliary Feedwater Pump | Engine Driven Auxiliary Feed Pump |
|---|---|---|---|
| Required Flow with one Steam Gen available, gpm | 180 | 180 | 200 |
| Required head with one Steam Gen Avail, ft | 2496 | 2502 | 2606 |
| Type | Centrifugal | Centrifugal | Centrifugal |
| No. of Stages | 8 | 2 | 8 |
| Maximum Pumping Temperature, °F | 120 | 120 | 120 |
| NPSH Required, ft | 10 (260 gpm) | 22.5 (300 gpm) | 16 (265 gpm) |
| NPSH Available, ft | 70 (280 gpm) | 70 (280 gpm) | 41 (265 gpm) |

The system piping material is ASTM A-106, Grade B and the safety class piping is USAS B31.7 1968, Class II and III. The non-safety class portion is designed and fabricated in accordance with USAS B31.1 1967 and ANSI B31.1 1986.

## 9.4.4 System Operation

The auxiliary feedwater system would be used in both the case of an emergency which makes the main feedwater system unavailable and the case of normal plant startup and shutdown. Examples of such emergencies are loss of power to the main feedwater pumps or seismic damage to the turbine building which would cause the main feedwater system to be unavailable and would result in steam generator low feedwater level.

Automatic Operation

Both the turbine driven and the motor driven auxiliary feed pumps are automatically started whenever the low feedwater level is reached in either steam generator; electrical power is supplied to the motor driven pump and the valves admitting steam to the turbine driven pump are opened. The operator, at his discretion, may shut down one pump. The air operated valves in the auxiliary feedwater system discharge flow path to the intact steam generator(s) open automatically if the low feedwater level setpoint has been reached. The AOV's will open and close to maintain set level.

Manual Operation

This system is routinely used for plant startup and shutdown under manual control and can also be manually controlled in an emergency. The system can be remote-manually operated from the control room (panels CB-10, AI-66A, and AI-66B) unless an emergency makes the control room unavailable; in this case, the system would be operable by a combination of local and remote-manual operations. The remote-manual operations for the steam driven pump and the air operated AFW discharge valves are carried out at alternate shutdown panel AI-179 located in the upper electrical penetration room. If no electrical power is available the operator can use the steam turbine driven pump, since instrument power only is necessary for this mode. If damage makes steam unavailable, the electric motor driven pump could be started locally at the pump. The non-safety class diesel driven pump can be started locally at panel AI-114 in the turbine building basement.

If the steam turbine driven pump is selected, the operator opens YCV-1045 and YCV-1045A or B from a switch located on AI-66B or AI-179. This admits steam to the turbine which then starts automatically. Then the operator uses valves HCV-1107B and HCV-1108B to regulate level in the steam generators. The speed of the turbine driven pump is governed by a differential pressure regulator which maintains the feed pump discharge pressure at a fixed differential greater than the steam inlet pressure to the pump's turbine.

If AC power is not available to power plant equipment, the differential pressure regulator fails in such a way that the pump operates at a speed determined by the speed limiting governor. At this speed, the pump will operate in an acceptable manner to supply feedwater to the steam generators. If instrument air is isolated to the differential pressure regulator, the effect is the same as a loss of AC power.

A single failure of the speed limiting governor could result in an overspeed condition for FW-10. A high pressure trip will isolate steam flow to the FW-10 turbine and ensure that the resulting pressure will not result in a failure of the FW-10 pump casing or discharge piping common to FW-10 and FW-6.

If steam was not available, the electric motor driven pump could be selected. The pump can be started manually from the control room, or by a push-button at the pump or by manually closing the circuit breaker in the switchgear bay. If necessary, the operator can manually load the pump motor onto the diesel generator bus. Steam generator level is controlled as before by valves HCV-1107B and HCV-1108B. The electric driven pump is a constant speed machine, so that the discharge pressure at reduced flow is considerably higher than at rated flow. The shutoff pressure of the electric motor driven pump is approximately 1200 psi.

The operator could select the engine driven auxiliary feedwater pump to feed the steam generators. The engine driven pump is normally aligned to the main feedwater system and can be started from the control room or locally at the pump. The engine driven pump is a constant speed machine with a shutoff pressure of approximately 1345 psig.

### 9.4.5 Design Evaluation

The auxiliary feedwater system provides a redundant means of supplying the steam generators with feedwater. Operation of the system is automatically initiated on receipt of AFAS (Auxiliary Feedwater Actuation Signal). The system can also be manually operated. Feedwater can be added to the steam generators under any credible condition, including the loss of all a-c power along with the unavailability of the main feedwater system and the unavailability of the main steam piping downstream of the main steam isolation valves.

The plant can be shutdown and decay heat removed for a time in excess of 4 hours in the absence of all AC power. Four hours is the duration of time the Station has been analyzed to cope with an electrical blackout. The turbine driven and engine driven auxiliary feedwater pumps require no AC power for operation nor do any valves or instrumentation required to introduce water in the steam generator. Feedwater for the turbine driven pump is available in the emergency feedwater storage tank, which can be provided with additional water if necessary, without the use of A.C. power. Decay heat is removed through the steam safety valves, which require no power (Ref. 9.4-1). In this scenario, the differential pressure regulator of the turbine-driven pump would not function due to the loss of instrument air and the pump would operate at a speed determined by the speed limiting governor.

A (manually aligned) alternate flow path from the safety-related pumps permits feeding the steam generators through the main feedwater headers independent of the normal AFW discharge flow path.

The emergency feedwater storage tank is located at a higher elevation than the turbine and motor driven auxiliary feedwater pumps and all valves between the tank and the pumps are open. The normally closed positions of auxiliary feedwater control valves HCV-1107B and HCV-1108B and regular surviellance of the leakage through the pump discharge check valves precludes the possibility of portions of the system draining down and creating air pockets during periods between pump operation. Upon startup of the system, the pumps will discharge into a filled system which will not produce hydraulic instabilities. Anytime maintenance is performed on the auxiliary feedwater system which alters valve alignments, an operator will check to ensure the valves are properly aligned to ensure an AFW flowpath to the steam generators. In addition, the system is tested monthly which results in pressurization of the discharge lines up to valves HCV-1107B and HCV-1108B.

The high energy line break (HELB) evaluation was included as part of the response to NUREG-0635. The discharge lines of the auxiliary feedwater pumps are designed to allow isolation of a break downstream of manual discharge valves FW-171 and FW-172 to permit supplying auxiliary feedwater through the main feedwater valves and supply piping. A discharge line break upstream of those valves is of very low probability due to the pipe design code, and periodic test and surveillance. The requirements of Standard Review Plan Section 10.4.9 and Branch Technical Position 10-1 are satisfied by this design. The engine driven Auxiliary Feedwater Pump discharge lines in Room 81 have been evaluated for HELB interaction with safety grade systems, components and structures. Jet impingement shields have been provided where necessary to preclude any unacceptable interactions.

In 1979, the NRC initiated a detailed nation-wide review of nuclear plant auxiliary feedwater systems. Fort Calhoun Station was a participant of that review. During that time NRC Safety Evaluation Reports (SERs) were issued detailing those reviews and documenting evaluations which showed that the current Fort Calhoun AFW system satisfies the requirements and provides safe and reliable operation. NRC reviews which were satisfied include:

| | |
|---|---|
| NUREG-0635, | "NRC Requirements for Auxiliary Feedwater Systems." |
| NUREG-0737, | "Clarification of TMI Action Plan Requirements." |
| NUREG-0578, | "TMI Lessons Learned Task Force Status and Short Term Recommendations." |
| IE Bulletin 80-04 | "Main Steam Line Break With Continued Feedwater Addition." |
| Generic Letter 81-04, | "Loss of Plant AC Power." |
| Generic Letter 81-14, | "Seismic Qualification of the Auxiliary Feedwater System." |

### 9.4.6 Availability and Reliability

The auxiliary feedwater system reliability complies with the reliability requirements of SRP Section 10.4.9. System reliability is achieved by diversity and separation of system components as well as the inherent reliability of individual system components (Ref. 9.4-2).

The water in the emergency feedwater storage tank is available to supply the steam turbine driven and motor driven pumps. The tank is constructed according to Section VIII of the ASME Boiler and Pressure Vessel Code. It is located in an accessible area, and exposed surfaces are readily accessible, so that an inspection of its exterior is possible at anytime. Interior inspection is possible during plant shutdown. Since oxygen is scavenged from this tank, no significant corrosion is expected. The valves in the supply line from the tank are in parallel and are locked open to preclude an inadvertent blockage of the supply. The suction source of the engine driven pump is the condensate storage tank located in the yard remote from the emergency feedwater storage tank.

The pumps were carefully specified, designed and constructed. The motor driven and engine driven pumps are entirely different in detail from the turbine driven pump. Therefore, the probability of a common mode failure as well as failure of an individual pump is very low. Each pump has sufficient capacity to remove decay heat following a reactor trip. The outside services required for each pump are minimal. The auxiliary feedwater system is an operational system as well as a safeguard system. Portions are used routinely during plant startup and shutdown. Routine use and/or testing demonstrate its excellent reliability and readiness.

In order to operate automatically, the turbine driven pump requires the following services:

a. Steam from the main steam line - Pneumatically operated valve YCV-1045 as well as YCV-1045A or YCV-1045B must be open.

b. D.C. electric power - To power the auxiliary oil pump.

c. Instrument air- Utilized for regulation of pump speed. If this air is not available, the pump will perform its function at maximum speed.

The engine driven pump does not rely on any outside services for its operation. Batteries provide engine starting and DC control power. The pumped fluid cools the engine and an engine mounted auxiliary generator can provide AC power requirements. A fuel oil day tank, and a fuel oil transfer pump that can be powered by the engine driven generator, are provided.

Admission of feedwater into steam generator RC-2A or RC-2B requires the use of valves HCV-1107A and B or HCV-1108A and B respectively. These valves are pneumatically operated and fail open. Each valve operator is provided with an accumulator sized for 8 hrs of operation after a loss of instrument air. However, when air is lost, valves HCV-1107B and HCV-1108B are not capable of modulation with hand controllers. Steam generator level instrumentation automatically controls feedwater flow. This instrumentation depends on D.C. power only. Manual regulation of the B valves can be performed from the control room and also can be performed locally. The turbine driven auxiliary feedwater pump recirculation valve FCV-1369 and motor driven auxiliary feedwater pump recirculation valve FCV-1368 also have air accumulators with 8 hours storage capacity. These valves fail open when the air reserves are depleted. The electric motor driven pump must have its recirculation valve closed to provide design flow at maximum design pressure.

The amount of water in the emergency feedwater storage tank, which supplies the electric motor and steam driven pumps, is adequate to remove decay heat for 8 hours. The heat is dissipated as steam through spring actuated steam line safety valves. The emergency feedwater storage tank capacity is maintained by manually supplying demineralized water as necessary for immediate availability during operation as specified in the Technical Specifications. Water sources are the condensate system, demineralized water and the outside condensate storage tank. In an emergency such that these alternate sources are not available, makeup water can be obtained from the raw water system.

The emergency feedwater storage tank is equipped with level indicators and alarms on high or low water levels.

The system can function in spite of the failure of any active component to respond. Heat can be removed, if necessary, from either of the two steam generators, so that failure of any one isolation valve or feedwater regulating valve can be tolerated. Either pump can be selected, so that failure of either pump or its power source can also be tolerated. The failure mode and effects analysis examined various component failures and various failures with line breaks (HELBs). Feedwater supply to at least one steam generator through either the AFW valves or the main feedwater valves was shown to be assured.

In the event of a loss of all ac power, the turbine-driven auxiliary feedwater pump would still be operational and would supply water to the steam generators from the emergency feedwater storage tank. The engine driven auxiliary feedwater pump would also be available to deliver flow from the condensate storage tank to the steam generators through the main feedwater system. The emergency feedwater storage tank contains enough water initially to remove decay heat from the steam generators for a minimum of eight hours. The tank can be resupplied with water from the condensate storage tank using the engine driven AFW pump.

An open, redundant manual bypass valve has been provided at the isolation valve on the emergency feedwater storage tank to the auxiliary feedwater pump(s) suction line to assure the availability of auxiliary feedwater in the event of a failure of the isolation valve. A check valve on the alternate flow path for the auxiliary feedwater system has been installed to prevent the pressurization of the auxiliary feedwater alternate flow path to normal feedwater system pressure.

Fort Calhoun Station has initiated several corrective actions in response to IE Bulletin 85-01 and Generic Letter 88-03, both related to steam binding of the auxiliary feedwater pumps. Surface mounted temperature instrumentation is installed on the discharge piping for FW-6 and FW-10 and is monitored by operators.

Procedures address corrective actions which would be taken in response to an elevated temperature condition in the AFW pump discharge lines. After feeding the steam generators via the main feedwater ring, Operating Instructions require operators to wait a few minutes after stopping the AFW pumps to ensure the positive seating of check valve FW-1334. The positive seating of this valve, along with closing applicable manual valves, should prevent the Main Feedwater System from pressurizing the Auxiliary Feedwater System and potentially steam binding the AFW pumps. (Ref. 9.4-3 and 9.4-4)

## 9.4.7 Tests and Inspections

The emergency feedwater storage tank was hydrostatically tested in the manufacturer's shop.

The motor driven and engine driven auxiliary feedwater pumps were hydrostatically and performance tested at the manufacturer's shop. Performance tests included head-flow characteristics, NPSH tests, and vibration testing. The units were examined for unsatisfactory operation such as noisy impellers, bearing overheating and excessive gland leakage.

Shop tests on the turbine driven auxiliary feed pump were similar except that complete performance testing was not possible since the manufacturer's boiler was limited to 600 psig.

After installation, the system was tested with regard to flow paths, flow and head capabilities, and operability. Pumps, valves, and controls were tested for operation at the proper set points.

AFW system operability is demonstrated during each plant startup during which feedwater is supplied to the steam generators by the motor driven pump. This demonstrates functioning of the pumping and delivery systems which would be called upon during an emergency.

A 72-hour endurance test was satisfactorily run on the steam turbine and motor driven pumps during which pump suction and discharge pressure, turbine oil temperature, steam supply pressure, motor current and bearing temperature and vibrations were recorded. The room ambient conditions (temperature and humidity) were also recorded and did not exceed environmental qualification limits for the safety related equipment in that room. Following the 72-hour continuous operation run, the pumps were shutdown, cooled down, and then restarted and operated for an additional hour.

The safety class portion of the system is tested in accordance with the station ISI Program and Technical Specification Surveillance requirements to demonstrate proper system readiness and valve position.

### 9.4.8 Specific References

9.4-1 Fort Calhoun Station Engineering Analysis No. 89-054, Station Blackout Coping Duration

9.4-2 NRC Letter 88-137, Resolution of Generic Issue No. 124, Auxiliary Feedwater System Reliability, May 9, 1988

9.4-3 Generic Letter No. 88-03, Steam Binding of Auxiliary Feedwater Pumps, February 19, 1988

9.4-4 IE Bulletin No. 85-01, Steam Binding of Auxiliary Feedwater Pumps, October 29, 1985

9.4.9 General References

9.4.9.1 NRC Safety Evaluation Report related to the implementations of recommendations for Auxiliary Feedwater Systems, February 2, 1981

9.4.9.2 NRC Safety Evaluation Report supporting Amendment Number 49 to the Fort Calhoun Technical Specifications, July 25, 1980

9.4.9.3 NRC Safety Evaluation Report related to the Seismic Qualification of the Auxiliary Feedwater System (Generic Letter 81-14), February 10, 1982

9.4.9.4 NRC Safety Evaluation Report related to Amendment Number 127 to the Fort Calhoun Station Technical Specifications, April 9, 1990

9.4.9.5 NRC Safety Evaluation Report related to Amendment Number 90 to the Fort Calhoun Station Technical Specifications, August 19, 1985 and to Generic Letter No. 83-37, November 1, 1981

9.4.9.6 Generic Letter No. 81-14, Seismic Qualification of Auxiliary Feedwater Systems, February 10, 1981

9.4.9.7 IE Bulletin No. 80-04, Analysis of a Main Steam Line Break with continued feedwater addition, February 8, 1980

9.4.9.8 NRC Bulletin No. 88-04, Potential Safety Related Pump Loss, May 5, 1988, WIP Number 060264

9.4.9.9 NRC Letter No. 82-104, Amendment No. 65 to FCS Facility Operating License, June 18, 1982

# 9.5 REFUELING SYSTEM

## 9.5.1 Design Bases

### 9.5.1.1 General

The refueling system provides for the storage and safe handling of fuel under all foreseeable conditions, from receipt of unirradiated fuel at the plant to shipment of irradiated fuel following radioactive decay. The design and construction of the system includes interlocks, travel and load limiting devices and other protective measures to minimize the possibility of mishandling or equipment malfunction that could damage the fuel and cause fission product release. Power operation of the system components is supplemented by manual backup to insure that the transfer of a fuel assembly can be completed in the event of a power failure.

### 9.5.1.2 Prevention of Criticality During Transfer and Storage

The transfer canal and pools for handling and storage of the fuel assemblies are filled with borated water in which the boron concentration is maintained at that value which will maintain the core at a $k_{eff}$ of 0.95 or less with all CEAs withdrawn from the core.

Spent fuel assemblies are stored in stainless steel racks consisting of vertical cells grouped in parallel rows with a center-to-center distance in Region 1 of 9.821" (E-W) x 10.363" (N-S) and 8.652" in both directions in Region 2. Both types of racks contain the neutron poison material Boral™. The Boral™ is attached as panels between each storage cell. The panels are protected with a stainless steel sheath. The racks are of rugged design to provide protection aganist mechanical damage to the fuel and the spacing is such that it is impossible to insert assemblies in other than the prescribed locations and to store more than a safe quantity of fuel. Borated water surrounds the spent fuel storage racks at the same concentration as, and to a level common with the refueling cavity and pool. The center-to-center distance of the storage racks is such that a $k_{eff}$ of less than 0.95 is maintained even in the event that the boron concentration is reduced to 500 ppm (Ref 9.5-6).

The spent fuel storage racks consist of two distinct regions. Region 1 can accept either new or irradiated fuel. Region 2, however, can accept only spent fuel meeting the minimum exposure requirements currently specified in Figure 2-10 of the Technical Specifications or if a full length CEA is inserted into the fuel assembly. The criticality analysis with CEA insertion assumed full CEA insertion during their residence in the core. This is conservative since the CEAs had only limited insertion during their exposure in the core. Even with full length insertion in the core it was still shown that the amount of $B^{10}$ remaining in the CEA was adequate to prevent exceeding the NRC criteria. A clip is attached to tie the CEA and fuel assembly together. The clip was designed such that it would not be able to be removed by the grapple on the fuel handling machine under normal handling conditions (Refs 9.5-4, 9.5-6, 9.5-8, 9.5.9.1).

Fuel can be moved directly from the reactor core or from Region 1 to Region 2 of the spent fuel pool after both a review and an independent verification of burnup adequacy have been performed. The fuel burnup determination is performed by surveillance test prior to fuel movement into Region 2.

The new fuel assemblies for a 1/3 core load are stored dry in rigid racks. The new fuel storage rack area was designed to be located on an elevated balcony above the general floor area to preclude flooding.

Should the need arise, an unirradiated fuel assembly stored in the Spent Fuel Pool may be removed and rinsed with unborated water. For this condition Keff will be maintained less than 0.95 provided the Fuel assembly's enrichment is less than or equal to 4.5 w/o U235 (Reference 9.5-10)

### 9.5.1.3 Fuel Storage Radiation Shielding

Adequate shielding for radiation protection of personnel is provided by the handling of irradiated fuel under not less than 10 feet of water. Mechanical stops are provided on all handling equipment which limit the height of withdrawal of the irradiated fuel to maintain the low level of radiation required for unrestricted occupancy of the area by personnel. The system is designed such that water cannot drain by gravity out of the fuel storage pool below the level of the top of the stored fuel in its storage rack (see Section 9.5.3.2).

9.5.1.4 Protection Against Radioactivity Release

Protection against the accidental release of radioactivity from irradiated fuel to the atmosphere is provided by the auxiliary building ventilation system, and by the containment air cooling and filtering system.

The ventilation air for both the containment and the spent fuel pool area flows through absolute particulate filters and radiation monitors before discharge at the ventilation discharge duct. In addition, the exhaust ventilation ductwork from the spent fuel storage area is equipped with a charcoal filter which will be manually brought on the line whenever spent fuel is being handled. This filter will absorb gaseous iodines in the unlikely event of a fuel handling incident resulting in the release of large quantities of radioactivity. (See Section 9.10.2 and 14.18)

9.5.1.5 Control Room Habitability

Protection from the accidental release of radioactivity for the control room operators is provided by the control room charcoal filters, VA-64A and VA-64B. One of the control room charcoal filter units is started prior to any irradiated fuel movement in the containment building or in the auxiliary building spent fuel pool storage area. New, unirradiated fuel movement does not affect control room habitability, unless it is moved over irradiated fuel, therefore, the control room charcoal filters need only be operated when new fuel is moved over irradiated fuel. Control Room filters need not be operated when new fuel is moved in the receiving/inspection storage area.

### 9.5.1.6 Spent Fuel Storage Rack Seismic Design

The spent fuel rack is a seismic category I structure. The design of the fuel racks is in compliance with the requirements of USNRC "OT Position Paper for Review and Acceptance of Spent Fuel Storage and Handling Applications", Section IV, and Standard Review Plan (SRP) (Ref 9.5-4). The rack is a free-standing structure consisting of discrete storage cells which are loaded with free-standing fuel assemblies. The response of a rack module to seismic inputs is highly nonlinear involving a complex combination of motions (sliding, rocking, twisting, and turning), resulting in impacts and friction effects. Linear methods such as modal analysis and response spectrum techniques cannot accurately simulate the structural response of such a highly nonlinear structure to seismic excitation. A correct simulation is obtained only by direct integration of the nonlinear equations of motion using actual pool slab acceleration time-histories to provide the loading. Therefore, as an initial step in spent fuel rack qualification, four sets of synthetic time-histories for three orthogonal directions are developed in compliance with the guidelines of Rev. 2 of USNRC SRP 3.7.1 and 3.7.2. In particular, the synthetic time-histories must meet the criteria of statistical independence and enveloping of the design response spectra.

To demonstrate structural qualification, it is required to show that stresses are within allowable limits and that displacements remain within the constraints of the contemplated design layout for the pool. This implies that impacts between rack modules, if they occur, must be confined to locations engineered for this purpose, such as the baseplate edge and possibly the upper region of the rack above the active fuel region. Similarly, rack-to-pool wall impacts, are engineered into the rack design and must be within stipulated limits. Impact loads between pedestal and liner must be assessed to assure liner integrity.

Rack dynamic simulations were performed in 3-D single rack 22-DOF model and in Whole Pool Multi-Rack (WPMR) model considering all 11 racks in the pool, respectively. A total of 24 single rack runs were performed for the heaviest rack in the pool, the rack with the maximum ration of side length and a Region I rack considering different values of friction coefficients and fuel loading patterns and assuming the worst earthquake (MHE). Two WPMR runs were performed assuming random distributed friction coefficients subjecting MHE and DE, respectively. All seismic analyses were performed based on both dry weight of 1380 lbs per regular fuel assembly and 2480 lbs per cell for future consolidation considerations.

A three-dimensional ANSYS finite element fatigue analysis was carried out on the representative new spent fuel rack which experiences the highest vertical support pedestal loading as characterized by the Whole Pool Multi-Rack analysis. Stress cycles are characterized by the cyclic life of the direct compressive load and the two friction loads acting on the pedestal. Bounding loads and number of cycles are obtained by examination of the relevant load time-histories for the pedestal chosen for detailed examinations. The number of imposed seismic events is 1 MHE and 10 DE.

The cumulative damage factor calculated to be 0.585 in conformance with the ASME Code indicates that is less than the Code allowable value of 1.0.

9.5.1.6.1 The 3-D 22-DOF Singles Rack Model

a. The fuel rack structure is rigid; motion is captured by modeling the rack as a twelve degree-of-freedom structure. Movement of the rack cross-section at any height is described by six degrees-of-freedom of the rack base and six degrees-of-freedom at the rack top. Rattling fuel assemblies within the rack are modeled by five lumped masses. Each lumped fuel mass has two horizontal displacement degrees-of-freedom. Vertical motion of the fuel assembly mass is assumed equal to rack vertical motion at the baseplate level. The centroid of each fuel assembly mass is located off center, relative to the rack structure centroid at that level, to simulate a partially loaded rack.

b. Seismic motion of a fuel rack is characterized by random rattling of fuel assemblies in their individual storage locations. All fuel assemblies are assumed to move in-phase within a rack. This exaggerates computed dynamic loading on the rack structure and therefore yields conservative results.

c. Fluid coupling between rack and fuel assemblies, and between rack and wall, is simulated by appropriate inertial coupling in the system kinetic energy. Fluid coupling terms for rack-to-rack coupling are based on opposed-phase motion of adjacent modules.

d. Fluid damping and form drag is conservatively neglected.

e. Sloshing is negligible at the top of the rack and is neglected in the analysis of the rack.

f. Potential impacts between rack and fuel assemblies are accounted for by appropriate "compression only" gap elements between masses involved. The possible incidence of rack-to-wall or rack-to-rack impact is simulated by gap elements at top and bottom of the rack in two horizontal directions. Bottom elements are located at the baseplate elevation.

g. Pedestals are modeled by gap elements in the vertical direction and as "rigid links" for transferring horizontal stress. Each pedestal support is linked to the pool liner by two friction springs. Local pedestal spring stiffness accounts for floor elasticity just above the pedestal.

h. Rattling of fuel assemblies inside the storage locations causes the gap between fuel assemblies and cell wall to change from a maximum of twice the nominal gap to a theoretical zero gap. Fluid coupling coefficients are based on the nominal gap.

9.5.1.6.2 Whole Pool Multi-Rack (WPMR) Model

The single rack 3-D (22DOF) model outlined in the preceding subsection is used to evaluate structural integrity, physical stability, and to initially assess kinematic compliance (no rack-to-rack impact in the cellular region) of the rack modules. Prescribing the motion of the racks adjacent to the module being analyzed is an assumption in the single rack simulations. For closely spaced racks, demonstration of kinematic compliance is further confirmed by modeling all modules in one comprehensive simulation using a Whole Pool Multi-Rack (WPMR) model. In WPMR analysis, all racks are modeled, and their correct fluid interaction is included in the model.

The presence of fluid moving in the narrow gaps between racks and between racks and pool walls causes both near and far field fluid coupling effects. A single rack simulation can effectively include only hydrodynamic effects due to contiguous racks when a certain set of assumptions is used for the motion of contiguous racks. In a WPMR analysis, far field fluid coupling effects of all racks are accounted for using the correct model of pool fluid mechanics. The external hydrodynamic mass due to the presence of walls or adjacent racks is computed in a manner consistent with fundamental fluid mechanics principles using conservative nominal fluid gaps in the pool at the beginning of the seismic event. Verification of the computed hydrodynamic effect by comparison with experiments is also provided.

The fluid flow model used to obtain the whole pool hydrodynamic effects reflects actual gaps and rack locations.

The friction coefficient is ascribed to the support pedestal/pool bearing pad interface consistent with Rabinowicz's data. Friction coefficients, developed by a random number generator with Gaussian normal distribution characteristics, are imposed on each pedestal of each rack in the pool. The assigned values are then held constant during the entire simulation in order to obtain reproducible results.

Thus, the WPMR analysis can simulate the effect of different coefficients of friction at adjacent rack pedestals.

In Whole Pool Multi-Rack analysis, a reduced degree-of-freedom (RDOF) set is used to model each rack plus contained fuel. The rack structure is modeled by six degrees-of-freedom. A portion of contained fuel assemblies is assumed to rattle at the top of the rack, while the remainder of the contained fuel is assumed as a distributed mass attached to the rack. The rattling portion of the contained fuel is modeled by two horizontal degrees-of-freedom.

Thus, the WPMR model involves all racks in the spent fuel pool with each individual rack modeled as an eight degree-of-freedom structure. The rattling portion of fuel mass, within each rack, is chosen to ensure comparable results from displacements predictions from single rack analysis using a 22-DOF model and predictions from 8-DOF analysis under the same conditions.

#### 9.5.1.7 New Fuel Storage Rack Seismic Design

The new fuel storage rack is a seismic Category I structure. Verification of the seismic I capability of the rack has been performed in Specific Reference 9.5-5. The rack is a free standing braced framed steel structure and is anchored to the supporting floor structure of the Auxiliary Building. New fuel assemblies are supported by a three tiered array of concentric funnels which are held in place by the structural frame. The rack loaded with new fuel, its anchorage, and supporting floor structure were analyzed using the finite element structural analysis program GTSTRUDL. The analysis demonstrated that these systems will not fail nor collapse assuming a worst case earthquake (MHE).

### 9.5.2 System Description

Refueling is accomplished by handling irradiated fuel assemblies underwater at all times. The refueling cavity and spent fuel pool are filled with borated water to a common level during refueling. The use of borated water provides a transparent radiation shield, a cooling medium, and a neutron absorber to prevent inadvertent criticality.

The refueling system provides a mechanism for transferring the fuel assemblies between the refueling cavity and the spent fuel storage pool through the transfer tube. The storage pool was originally designed to accommodate 178 fuel assemblies (1-1/3 cores) and the spent fuel shipping cask. The capacity of the spent fuel storage pool was subsequently increased to 483 fuel assemblies (3-2/3 cores). In 1983, the spent fuel pool storage capacity was increased to 729 fuel assemblies (5½ cores). In 1994, the spent fuel pool storage capacity was increased to 1083 fuel assemblies (8 cores). Spent CEAs are stored in the spent fuel assemblies.

The refueling machine removes a spent fuel assembly from the core and transports it to the transfer carrier which is in the vertical position. The carrier is then rotated from the vertical position to the horizontal position by the upending mechanism and is moved through the transfer tube to the spent fuel storage pool by the transfer mechanism. The carrier is then rotated to a vertical position and the spent fuel assembly is removed and placed in a storage rack by the spent fuel handling machine. The spent fuel handling machine is designed to remove the fuel from the storage rack and deposit it in a shipping cask for off-site shipment.

During all handling operations, a sufficient water shield is maintained over the top of the fuel assembly to restrict radiation exposures to operating personnel. The refueling water boron concentration is checked periodically to ensure adequate shutdown margins. A minimum concentration of 500 ppm boron must be maintained in the spent fuel pool to prevent criticality during accident conditions (abnormal location of a fuel assembly; Ref. 9.5-6 ). The pool is normally maintained at the refueling boron concentration. This concentration can vary from cycle to cycle. The current cycle requirements are noted in Section VI of the Technical Data Book.

New fuel assemblies are stored dry in the new fuel storage area. These are provided with vertical racks to hold 48 replacement assemblies. One cell is prohibited from being used as a fuel storage cell, see Table 9.5-1. These racks are designed to preclude criticality even if flooded (Ref. 9.5-1). New fuel assemblies are transported from the storage rack to the new fuel elevator by means of the spent fuel handling machine (FH-12). The new fuel elevator receives the fuel assembly in its raised position and then travels to the bottom of the fuel pool. The fuel assembly is then picked up by the spent fuel handling machine for transportation to the transfer carriage or spent fuel rack. In the event that unirradiated fuel needs to be prepared, these unirradiated assemblies will be raised using the new fuel elevator following strict administrative controls. The layout of the refueling system in Containment is shown in Figure 9.5-1. Selected fuel storage data is provided in Table 9.5-1.

### 9.5.3 System Components

9.5.3.1 Refueling Cavity

The refueling cavity is a reinforced concrete structure with a stainless steel liner that forms a pool above the reactor. During refueling, the cavity is filled with borated water to a depth which limits the radiation at the surface of the water attributed to irradiated fuel in the core to ALARA.

To prevent leakage of refueling water from the cavity, the flange of the reactor vessel is temporarily sealed to the bottom of the refueling cavity. The seal is installed after reactor cooldown but prior to the removal of the reactor vessel head and flooding of the reactor cavity.

The reactor cavity also provides storage space for the upper guide structure, irradiated in-core instrumentation, miscellaneous refueling tools and the core support barrel when its removal is required. The reactor vessel head and the missile shields are stored on the operating floor.

9.5.3.2 Spent Fuel Storage Pool

The spent fuel storage pool is located outside the containment at the west side of the auxiliary building. The pool was designed for the underwater storage of spent fuel assemblies and CEAs after their removal from the core. Decay heat is removed by the cooling system described in Section 9.6. The pool was constructed of reinforced concrete and the entire wetted surface is lined with stainless steel plate. It was designed to support all dead and live loads including hydrostatic loads, temperature gradients, and the effects of tornadoes and the maximum credible earthquake. Drainage grooves are provided behind the stainless steel liner to permit detection of any liner leakage.

Design of the pool and its cooling system and connections to the pool are such that the pool cannot be drained below the level of the top of the stored fuel when in its storage rack. The top of a fuel assembly in a storage rack is about the same elevation as the bottom of the gate connecting the pool with the fuel transfer canal which is at elevation 1008'-6". A plate has been installed across the bottom of the gate opening to raise the minimum possible water level in the pool to 1009'-8.5".

There are no pipes in the pool below this elevation. The water inlet line enters the pool at elevation 1034'-0" and terminates at elevation 1031'-7". The drain line enters the pool and terminates at elevation 1011'-4". When AC-187 located just outside the pool wall on the lower suction line is closed, the pool is protected from any ruptures of the line beyond the valve. The line is designed such that a rupture between the valve and the pool wall could not drain the pool below elevation 1011'-0".

Spent fuel assemblies are handled by underwater tools which are operated from a platform on the spent fuel handling machine. The tools are attached to the hoist by a safety connection and are stored in fixtures on the pool wall when not in use. New assemblies are transferred from the new fuel storage racks to the new fuel elevator using a short tool. This tool is normally stored on the spent fuel handling machine when not in use.

#### 9.5.3.3 New Fuel Storage

The new fuel is stored dry in racks in the auxiliary building conveniently located for receiving and transferring of these assemblies. New CEAs are inserted in the new fuel or dummy fuel assemblies for storage. Calculations confirm that the new fuel storage vault in the dry condition can safety accept fuel enriched up to 5.0% with a $K_{eff}$ well within the current Technical Specification limit, Ref. 9.5-1.

#### 9.5.3.4 Major Handling Equipment

The handling equipment includes the head lift rig, the internals lift rig, the refueling machine, the upending machines, the transfer carriage, the new fuel elevator, the spent fuel handling machine, and the associated controls and communication equipment. Details of the construction, design and function of this equipment are presented in Section 9.5.4.

Table 9.5-1 - "Refueling Equipment Data"

| | |
|---|---|
| New Fuel Storage Rack | |
| Core Storage Capacity | 1/3 |
| Equivalent No. of Fuel Assemblies | 47* |
| Center-to-Center Spacing of Assemblies, inches | 16 |
| Spent Fuel Storage Pool | |
| Core Storage Capacity | Region 1 - 1.2 Cores<br>Region 2 - 6.9 Cores |
| Equivalent No. of Fuel Assemblies | 1083 |
| Number of Space Accommodations for Spent Fuel Shipping Casks | 1 |
| Center-to-Center Spacing for Assemblies, inches | Region 1 - 10.363" x 9.821"<br>Region 2 - 8.652" |
| Maximum $K_{eff}$ Without Borated Water | Ref. 9.5-6 |
| Miscellaneous Details | |
| Wall Thickness of Spent Fuel Storage Pool, ft | 2 to 5-1/2 |
| Weight of Fuel Assembly, lb (rack design) | 1380 |
| Capacity of SIRW Tank, gal | 314,000 |
| Quantity of Water Required to Fill Refueling Cavity, gal | 249,500 |
| Spent Fuel Storage Pool Volume, gal | 215,000 |

* Rack cell B2 is prohibited from being used as a storage cell.

## 9.5.4 System Operation

### 9.5.4.1 Reactor Vessel Head Lifting Rig

The head lifting rig is composed of a removable three-part spreader bar assembly, a three-part column assembly which is attached to the seismic support skirt, and the rigging necessary to lift and move the head to the storage area. The column assembly provides a working platform for personnel during maintenance, supports the three hoists which are provided for handling the hydraulic stud tensioners, the studs, washers and nuts, and links the spreader bar assembly with the seismic support skirt and the head.

9.5.4.2 Internals Lifting Rig

The internals lifting rig consists of an instrument elevator assembly and a structural lifting rig for attachment to the main containment building crane. Three spreader arms are supported by the lift rig in delta arrangement; pipe legs are attached to these spreader arms.

To lift the upper guide structure for refueling, each pipe leg carries a hollow attachment bolt which is threaded into the upper guide structure. In the event that removal of the core support barrel is required, an additional bolt is inserted through each upper guide structure attachment bolt and threaded into the core support barrel; the upper guide structure and the core support barrel are lifted and removed together.

The function of the instrument elevator assembly is to attach the in-core instrumentation retraction structure to the building crane; it also serves as an access platform for instrument line servicing during refueling.

9.5.4.3 Refueling Machine

The refueling machine is a traveling bridge and trolley which spans the refueling cavity and moves on rails located on the 1038'6" elevation floor of the containment building. The bridge and trolley motions allow coordinate location of the fuel handling mast and hoist assembly over the fuel in the core. The hoist assembly contains a coupling device which, when rotated by the actuator mechanism, engages the fuel assembly to be removed. The hoist assembly is moved in a vertical direction by a cable that is attached to the swivel top of the hoist assembly and runs over a sheave on the hoist cable support to the drum of the hoist winch. After the fuel assembly is raised into the hoist and the hoist into the refueling machine mast, the refueling machine transports the fuel assembly to another location or to the carrier assembly.

The controls for the refueling machine are mounted on a console located on the refueling machine trolley. Coordinate location of the bridge and trolley is indicated at the console by digital readout devices which are driven by encoders coupled to the guide rails through rack and pinion gears. A system of pointers and scales is provided as a backup for the remote positioning readout equipment.

Manually operated hand wheels are provided for bridge, trolley and winch motors in the event of a power loss.

During withdrawal or insertion of a fuel assembly, the load on the hoist cable is monitored at the control console to ensure that movement is not being restricted. A zoned mechanical interlock is provided which prevents opening of the fuel grapple and protects against inadvertent dropping of the fuel. A piston operated spreader device is provided which spreads adjacent fuel assemblies within the core to provide unrestricted removal and insertion. This spreader is part of the hoist assembly and can be operated before grappling of the fuel assembly when required. The safety features of the refueling machine are:

a. An anti-collision device on the refueling machine mast which stops bridge and trolley motion. This device consists of a hoop and limit switches to protect the mast from hitting the vessel alignment pins, structures within the refueling cavity or the walls of the refueling cavity;

b. Interlocks which restrict simultaneous operation of either the bridge or trolley and the hoist winch drive mechanism;

c. An interlock which prevents bridge and trolley motion when the spreader device is extended;

d. An interlock which prevents bridge and trolley motion when the hoist is loaded and below the hoist box down stop;

e. An override switch which must be actuated after fuel hoist operation to allow bridge or trolley motion;

f. Over and underload switches which stop fuel hoist motion;

g. Underload Bypass switch to allow lowering an empty hoist box;

h. Bridge and trolley speed restriction zones over the reactor core;

i. Fuel hoist speed restriction;

j. An interlock which prevents positioning of the refueling machine over the upending machine unless the upending machine is in the vertical position.

#### 9.5.4.4 Upending Machines

Two upending machines are provided, one in the containment building and the other in the fuel storage area. Each consists of a structural steel support base from which is pivoted an upending straddle frame which engages the two-pocket fuel carrier. When the carriage with its fuel carrier is in position within the upending frame, the pivots for the fuel carrier and the upending frame are coincident. Hydraulic cylinders attached to both the upending frame and the support base rotate the fuel carrier to the vertical position and then to the horizontal position as required by the fuel transfer procedure.

Interlocks are provided to ensure the safe operation of this equipment by preventing inadvertent rotation of the tilting cylinders while FH-1 is in the upender zone, and by deactivating the cable drive so that a premature attempt to move the carriage through the transfer tube cannot be initiated.

#### 9.5.4.5 Transfer Carriage

A transfer carriage is provided to transport the fuel assemblies between the refueling pool and the fuel storage area. Eight large wheels, four on each side support the carriage and allow it to roll on tracks within the transfer tube. Track sections at both ends of the transfer tube are supported from the pool floor and permit the carriage to be properly positioned to the upending mechanism. The carriage is of sufficient length so that it can be driven from one end of the transfer system by means of steel cables connected to the carriage and hence through sheaves to its driving winch mounted at elevation 1056'-8". A two-pocket fuel carrier is mounted on the carriage and is pivoted for tilting by the upending machines.

#### 9.5.4.6 Transfer Tube and Isolation Valve

The fuel transfer tube connects the refueling pool with the fuel storage areas. During reactor operation, the transfer tube is closed by an isolation valve outside the containment and a blind flange inside the containment. The tube is supported by a larger diameter pipe which, in turn, is sealed to the containment envelope. The two concentric tubes are sealed to each other with a bellows expansion joint (see Figure 5.9-9).

### 9.5.4.7 Transfer Rails

The transfer carriage rides on the transfer rails when moving between the reactor cavity and fuel storage area. The rail supports sit on and are welded to the transfer tube. The rail assemblies were fabricated to a length which allowed them to be lowered for installation in the transfer tube. A gap is left in the track at the valve on the fuel storage side of the transfer tube to allow closing of the valve.

### 9.5.4.8 Spent Fuel Handling Machine

The basic structure of the handling machine is a traveling bridge which spans the spent fuel pit and moves on rails so as to provide area coverage for both new and spent fuel storage positions, the new fuel elevator and the transfer system tilt machine. A trolley and fuel hoist are mounted on the bridge structure and travel horizontally at 90° to the bridge travel. The hoist hook supports either of two handling tools for grappling fuel assemblies. In operation, the hoist hook and tool are located over the fuel assembly by rectangular coordinate positioning of the bridge and trolley. Grapple load indication and limits are provided to prevent unusual loads during removal and insertion operations. The rotation of fuel is manually controlled via the grapple tool. A portable handling tool is used to install, remove, and reposition Control Element Assemblies (CEAs). Manipulation of the CEAs is performed in the spent fuel pool, with the operator working from spent fuel handling machine FH-12. The same handling tool is also used for manipulation of flow plugs.

### 9.5.4.9 New Fuel Elevator

A fuel elevator is provided to lower new fuel from the operating level at the top of the transfer canal to the bottom of the canal where it is grappled by the long grapple tool. The elevator is powered by a cable winch and fuel is contained in a simple support structure whose wheels are captured in two rails. New fuel is loaded into the elevator by means of the hoist and short grapple tool.

#### 9.5.4.10 Communications

Direct audible communication between the control room and the refueling machine operator is available whenever changes in core geometry are taking place (Reference 9.5-9). This provision allows the control room operator to inform the refueling machine operator of any impending unsafe conditions detected from the main control board indicators during fuel movement. Direct communication is also provided between the refueling machine operator and the spent fuel pool area.

#### 9.5.4.11 Personnel Safety Features

Safety nets over the fuel transfer canal and the new fuel storage area (Room 25A) provide protection against personnel falling from the 1038' -6" level of the spent fuel deck. The removable safety net over the fuel transfer canal is 5' wide by 21' long. The removable safety net over the new fuel storage area is 25' wide by 21' long.

### 9.5.5 Design Evaluation

Underwater transfer of spent fuel provides ease and safety in handling operations. Water is an effective, transparent radiation shield and an efficient cooling medium for removal of decay heat. Basic provisions to ensure the safety of refueling operations are:

a. Gamma radiation levels in the containment and fuel storage areas are continuously monitored (see Section 11.2.3 and Reference 9.5-9). These monitors provide an audible alarm at the initiating detector and in the control room, indicating an unsafe condition. Continuous monitoring of reactor neutron flux, with indication in the control room, provides immediate indication and alarm of an abnormal core flux level.

b. Whenever new fuel is added to the reactor core, the source range neutron flux (count rate) is recorded to verify the subcriticality of the core.

c. To prevent fuel assemblies from swinging into the wall during fuel movement in the spent fuel pool, limit switches provide a means of enforcing low speeds around the perimeter of the pool as well as providing bridge and trolley lockouts to prevent collision with the walls of the pool. A Limit Bypass Switch allows travel beyond the lockouts to access the perimeter Fuel Rack locations.

d. The design of the equipment places physical limits on the extent of fuel movement, thereby avoiding the possibility of raising fuel beyond a safe limit. Fuel storage rack spacing provides positive protection against criticality in the event of inadvertent flooding of the fuel storage area with unborated water. The design of the fuel storage pool is such that water cannot drain out of the pool by gravity below the level of the top of stored fuel (see Sec 9.5.3.2) and the elevated new fuel storage area cannot be flooded.

e. In the unlikely event that a spent fuel cask falls into the spent fuel pool, the stainless steel liner could be punctured; however, the 12-foot thick reinforced concrete mat below the pool would not be penetrated and leakage of water from the spent pool would be slow. The spent fuel makeup system can provide 500 gpm and additional water is available from both the demineralized water system and the fire protection system using hoses.

## 9.5.6 Availability and Reliability

All of the equipment in the system is manually operated, i.e., there are no automatic functions requiring logic control. Manually operated handwheels are provided to allow bridge, trolley and hoist motion in the event of a power loss.

The fuel transfer carriage is longer than the fuel transfer tube, assuring that one end of the carriage is accessible at all times during the transfer operation. Operability of the refueling system is assured by functional testing (to include a load test on fuel handling cranes that will be required to handle spent fuel assemblies), prior to commencing refueling operations.

The applicable fuel handling equipment is tested not more than 14 days prior to moving fuel and is retested thereafter whenever the equipment is idle for more than 14 days. Maintenance which effects interlocks and/or setpoints also requires that the equipment be retested prior to using it to move fuel.

### 9.5.7 Tests and Inspections

The refueling equipment was partially assembled at the fabricator's facility and each component tested for correctness of operation, after which it was shipped directly to the site where the complete system was installed and tested.

The refueling machine is essentially identical to the Palisades machine which was shipped to Combustion Engineering, Windsor, Connecticut and which satisfactorily completed an extensive acceptance and performance test program.

The refueling machine was mounted on rails over a core and pressure vessel mockup and the upending machines were positioned in an adjacent pit with a simulated transfer tube between them. The following refueling operations were performed:

a. Indexing the refueling machine to the fuel assembly in the core;

b. Engaging and lifting the fuel assembly into the fuel hoist;

c. Indexing the refueling machine to the tilting machine and lowering the fuel assembly into the carriage;

d. Operation of the transfer system, upending the carriage to the horizontal, transferring it through the simulated refueling tube to the spent fuel pool upending machine, and upending the carriage back to the vertical.

### 9.5.8 Specific References

9.5-1 Criticality Safety Evaluation of the Ft. Calhoun New Fuel Storage Vault, EA-FC-94-029, Rev 0.

9.5-2 Deleted

9.5-3 Deleted

9.5-4 LIC-92-340A Licensing Report for Spent Fuel Storage Capacity Expansion, FLC-92-005, 07/07/92.

9.5-5 EA-FC-95-020, Rev. 0, Seismic and Safety Evaluation of New Fuel Storage Rack.

9.5-6 Criticality Safety Evaluation of the Ft. Calhoun Spent Fuel Storage Rack for Maximum Enrichment Capability, EA-FC-96-01, Rev. 0.

9.5-7 Deleted.

9.5-8 CEA Clips for Locking CEA's to Fuel Assemblies for Region 2 Discharge, EA-FC-92-11, Rev. 0, May 28, 1992.

9.5-9 NRC Amendment 188 to Technical Specifications, December 31, 1998.

9.5-10 EMF-P66-550, Rev. 15, "Standard Operating Procedure-Fuel Bundle Wash Station", Siemens Power Corporation, December 20, 1999.

## 9.5.9 General References

9.5.9.1 NRC Safety Evaluation Report Related to Technical Specification Amendment 133, October 2, 1990.

9.5.9.2 NRC Safety Evaluation Report Related to Technical Specification Amendment 13, July 2, 1976.

9.5.9.3 NRC Safety Evaluation Report Related to Technical Specification Amendment 75, September 9, 1983.

9.5.9.4 NRC IE Bulletin No. 78-08, Radiation Levels From Fuel Element Transfer Tubes, June 12, 1978.

9.5.9.5 NRC Safety Evaluation Report Related to Technical Specification Amendment 174, July 30, 1996.

9.5.9.6 NRC Safety Evaluation Report Related to Technical Specification Amendment #155, (Spent Fuel Storage Racks) August 12, 1993.

9.5.9.7 Supplement to NRC Safety Evaluation Report Related to Technical Specification Amendment #155, (Spent Fuel Storage Racks) April 9, 1996.

# 9.8 RAW WATER SYSTEM

## 9.8.1 Design Bases

The raw water system was designed to provide a cooling medium for the component cooling water system. The system is rated for the maximum duty requirements that may occur during shutdown or accident modes of operation. The heat transferred to the raw water is discharged to the river. The water temperature can vary between 33°F in winter to a maximum of 90°F in summer. For protection against a complete failure of the component cooling system, raw water can be diverted to cool engineered safeguards equipment.

The system was designed and constructed to seismic Class I standards (see Appendix F).

## 9.8.2 System Description

Four raw water pumps are installed in the intake structure pump house to provide screened river water to the component cooling heat exchangers. The pump discharge piping is arranged as two headers which are interconnected and valved at the pumps and in the auxiliary building. Each header was designed to accommodate sufficient flow to the component cooling heat exchangers to support normal modes of plant operation. System pressures, flows and valve positions are displayed in the control room. Water level instrumentation in the intake structure will alarm in the control room if water from any source should endanger the raw water pumps. A majority of the system operational and control functions can be performed from the control room. The flow diagram is shown in P&ID 11405-M-100.

In the unlikely event of a complete failure of the component cooling water system, raw water direct cooling capability exists for the shutdown cooling heat exchangers, control room air conditioning waterside economizers, safety injection and containment spray pump coolers, and the containment air cooling coils. Raw water direct cooling is utilized via normally handjacked locked closed valves. In the event of a complete loss of component cooling water, raw water direct cooling of the shutdown cooling heat exchangers would be needed for long-term decay heat removal after a large LOCA. Cooling water is not required as a heat sink for the control room air conditioners because they have air-cooled refrigerant condensers. Raw water direct cooling may be used for the control room A/C waterside economizers, if desired. Raw water may be utilized for direct cooling of the safety injection and containment spray pumps if locally accessible. They may be inaccessible post-RAS, however the pumps can perform their post-accident function without cooling water. Raw water direct cooling to the containment air coolers is not required for containment peak pressure suppression. Raw water may be used for direct cooling of the containment air cooling coils if containment atmospheric temperature is less than 150°F. Raw water is credited as backup to CCW for fire events as described in Appendix R, Safe Shutdown Analysis. Raw water is also credited in the Fire Safe Shutdown Analysis and the Seismic Safe Shutdown Analysis equipment list for makeup to the Emergency Feedwater Storage Tank, FW-19.

Raw water direct cooling will not be available when the system is out of service for maintenance. This will only occur in Mode 5 and Shutdown Condition 2. This condition is acceptable due to the short outage duration, close attention to the fuel pool heatup rate, and the availability of makeup water sources.

The two raw water lines between the intake structure and the auxiliary building are buried in separate trenches. At the point where raw water piping enters a building, the detail shown in Figure 9.8-2 is employed. The outside guard pipe absorbs forces imposed by the soil in the event of an earthquake. During an earthquake, differential movement between the auxiliary building and the surrounding earth occurs, since the building is connected to bedrock via piles. The process pipe can flex inside the guard pipe, where it is free of soil reactions, enough to absorb the movement between the building and the surrounding earth.

## 9.8.3 System Components

The design and operating design characteristics of the major raw water system components are shown in Table 9.8-1.

Table 9.8-1 - "Raw Water System, Design and Operating Data"

Raw Water Pumps, Item No.'s AC-10A, 10B, 10C & 10D

| | | |
|---|---|---|
| Number Installed | 4 | |
| Type | Vertical, Mixed Flow | |
| Pump characteristics: | Flow, gpm per pump | TDH, ft |
| Nominal Flow and TDH | 5325 | 118 |
| Design Pressure, psig | 150 | |
| Design Temperature, °F | 150 | |
| Materials of Construction: | | |
| Bowl | AISI 4330 or approved equivalent | |
| Impeller | AISI 4330 heat treated or approved equivalent | |
| Shaft | Type 410 stainless steel | |

Piping

| | |
|---|---|
| Design pressure | 150 psig |
| Design temperature | 500°F |
| Code | USAS B31.7 1968, Class II/Class III and B31.1 1967 |
| Material | Seamless ASTM A106, predominantly. Some high-wear spool pieces are ASTM A312 Grade TP304 or TP304L. See Raw Water P&IDs for details. |

## 9.8.4 System Operation

### 9.8.4.1 Normal Operation

The system is remotely operable from the control room. Raw water flow is normally maintained through at least two component cooling heat exchangers. The number of component cooling heat exchangers in service (i.e., having both raw water and component cooling water flow through them) during normal plant operation is a function of river temperature and the amount of cooling capability needed. This is described in more detail in Section 9.7.4.1.

### 9.8.4.2 Shutdown Operation

During shutdown cooling, raw water pumps and heat exchangers are placed in service as required to reduce the reactor coolant temperature. Refer to Section 9.7.4.2.

### 9.8.4.3 Post-DBA Operation

In the unlikely event of a DBA all four RW pumps are started automatically and the eight heat exchanger isolation valves are opened from a safety injection actuation signal (SIAS) and the eight heat exchanger isolation valves are opened. Additionally, SIAS override to the RW isolation valves is provided so the operator may close/isolate one or more RW heat exchangers.

The failure of a single active component is postulated in conjunction with a DBA. The most limiting single failure is that which results in the least amount of heat removal capability from the CCW System. If all normal power sources are lost and only one emergency diesel-generator functions, a minimum of two raw water pumps would operate if the river water temperature is greater than 60°F. When the river water temperature is below 60°F, one raw water pump may be in an inoperable condition in accordance with Technical Specification 2.4.1.c. Therefore, a minimum of one raw water pump would operate after a diesel generator failure if the river water temperature is below 60°F.

As discussed in Section 9.7.4.3, the raw water system is manually directed to provide direct cooling of the required DBA controlling equipment if the CCW system is not available due to a break or failure of CCW system equipment. However, the failure of an active component and a CCW system break are not both postulated. In addition, a CCW system break is not assumed to occur in the short term after an accident.

## 9.8.5 Design Evaluation

The raw water system was designed to provide sufficient flow and head capability to maintain the component cooling water at a maximum return temperature of 110°F during normal operation. In addition, the system is capable of satisfying the design criteria under post-DBA conditions with the single failure of an active component and a loss of instrument air. Analyses demonstrate that raw water flow to the CCW heat exchangers would be adequate for removing post accident design basis heat loads while maintaining a maximum CCW return temperature of $\leq$158°F.

River level/temperature limits are observed for some off-normal raw water system operating alignments. The river condition limits are based on calculations which use the low-limit hydraulic performance for the raw water pumps. The river condition limits, in conjunction with the minimum required raw water pump performance, ensure that if a DBA occurs while in an off-normal alignment, subcooled conditions will exist in the RW discharge header and CCW return temperature will be at or below the maximum post-DBA temperature specified in Section 9.7. The raw water pump minimum hydraulic performance limit is chosen by OPPD. The river condition limits are a function of the chosen raw water pump performance limit, because the cooling performance of the Raw Water system is a function of river conditions as well as pump hydraulic performance. The river condition limitations are documented in the Technical Data Book.

Raw Water flow is normally maintained through four component cooling heat exchangers when river temperature is greater than or equal to 70°F. This eliminates the potential failure of a RW valve to open as a credible single active failure.

The raw water system is capable of providing direct cooling of the required DBA controlling equipment if the CCW system is not available. Analyses demonstrate that adequate flow would be provided to the required equipment and that the temperature of the raw water returning to the river would be less than 210°F with the river at its peak temperature of 90°F.

### 9.8.6 Availability and Reliability

The system piping between the intake structure and the auxiliary building was designed as a two 20 inch header system. The discharge piping from the four pumps is manifolded, valved and instrumented to permit operation or isolation of any pump. Sufficient flow is available, under any normal mode of operation, even if one of the two supply headers should rupture. Redundant pumping capacity is provided.

To ensure system integrity in the event of an earthquake, each 20 inch header is encased in a 28 inch cast-in-concrete guard pipe in the south wall of the auxiliary building.

The emergency diesel-generators ensure a power supply if the off-site power is interrupted and either generator operates sufficient equipment to provide the design post-DBA cooling.

Air accumulators inside the intake structure provide instrument air to operate the raw water system valves in the intake structure even upon failure of the compressed air system.

Water level instrumentation in the intake structure will alarm in the control room if water from any source should endanger the raw water pumps.

Protection for the raw water pumps and their drives against floods is provided at three elevations as indicated on Figure 9.8-1. The pumps are permanently protected against any water level up to elevation 1007.5 feet by the Class I concrete substructure of the intake building. Protection is provided to elevation 1009.5 feet by gasketed steel closures which are provided for all openings in the reinforced concrete perimeter wall extending upward from the main operating level. Supplementing the wall with sandbags provides protection to elevation 1014.5 feet. For water levels above 1007.5 feet, the water level inside the intake structure is controlled by positioning the exterior sluice gates to restrict the inflow into the wet walls to match the rate of pumped outflow. Because of the wide head variations possible, the sluice gate and pump settings are automatic self-balancing within reasonable limits.

The following water levels were considered in computing the theoretical river levels:

| | |
|---|---|
| 983.0 feet | During the winter, water releases are normally controlled to maintain this level. |
| 992.0 feet | During the navigation season, this level is required. |
| 998.0 feet | Stage duration level exceeded only 1% of the time. |
| 1001.3 feet | Peak level of a 1% probability flood. |
| 1004.2 feet | Peak level of the designed flood. |

Theoretical flood levels:

| | |
|---|---|
| 1009.3 feet | Computed peak level flood resulting from the simultaneous occurrence of: |

1. The maximum probable rain storm and runoff downstream from Gavins Point;

2. The maximum outflow from Gavins Point resulting from a maximum probable rain storm and runoff upstream from Gavins Point.

There is a two day lag between the release of a peak flow at Gavins Point and its arrival at the Fort Calhoun Station.

| | |
|---|---|
| 1013 feet to 1014 feet | Approximately computed peak level resulting from the simultaneous occurrence of: |

1. The conditions No. 1 and 2 as shown in the 1009.3 peak;

2. A catastrophic, instantaneous disintegration of Fort Randall Dam superimposing all of the water impounded behind it on the conditions described above.

The combination of events resulting in a flood level of elevation 1013-1014 feet is considered incredible. If a catastrophic instantaneous disintegration of Fort Randall Dam should occur, however, there is a three-day time lag before flood arrival at the Fort Calhoun Station.

The intake structure is a massive concrete building set just back of the harbor line of the river. The noses of all of the intake or recirculation channels are armored with anchored steel plates. The river bottom slopes downward from the bank to the thread of the channel, thus keeping boats and barges away from the actual harbor line. Any blow that could be struck by such a vessel would be a glancing one at worst on the armored wall noses and any damage to the structure itself is considered unlikely. Even a flood or storm driven barge which might strike the intake structure could not conceivably block flow sufficiently in the three sections of the structure to decrease the flow from the raw water pumps. The intake structure consists of three bays separated by concrete walls perpendicular to the river; two cells contain one raw water pump each and one cell contains two. Flow through each cell is independent of the other two, and the raw water pumps are located 35 feet back from the river. Icing conditions at the river water entrance of the intake structure are prevented by routing a portion of the warm water from the circulating water discharge tunnel back upstream of the intake screen. Experience with the District's stations on the Missouri River shows that, by controlling the amount of water being recirculated, potential icing conditions can be averted.

The Corps of Engineers adjusts winter releases from Gavins Point as necessary to accommodate the needs of all Missouri River water users. Normally, the water level is maintained higher than 983.0 feet. Although agreement between OPPD and the Corps of Engineers to maintain minimum river water levels has not been formalized, the Corps of Engineers does cooperate with OPPD in these matters and would provide additional flow from upstream dams if such conditions would be impending. The time required for severe ice blockage of the river to occur extends into many hours and the weather conditions which would cause blockage would be evident over a period of a few days. Even lower river water levels would not be detrimental to plant safety since the minimum submergence on the raw water pumps is 976 feet 9 inches or more than six feet below the controlled minimum river water level.

An evaluation has been performed of the flooding consequences of a postulated pipe failure involving a system in or above the raw water pump rooms (fire protection, raw water, screen wash). Since these are not high-energy systems (pressure <275 psig and temperature <200°F), the "postulated pipe failure" is a through-wall pipe crack, with the crack size being half the pipe diameter in length and half the pipe thickness in width. The evaluation shows that for any single postulated pipe failure, ample time is available to implement operator actions to isolate the leak before the raw water pump room water level reaches the raw water pump motors.

In the unlikely event all raw water pumps are unavailable, cooling water can be obtained from the fire protection system and its diesel or electric driven fire pumps to provide some base load cooling until raw water can be restored. This system interconnection would be made between the raw water/component cooling water heat exchangers and local fire hose cabinets. Operator actions required for this interconnection are included in one of the plant's abnormal operating procedures.

Should the raw water system become inoperable, the reactor can be stabilized by removing decay heat through the steam generators.

## 9.8.7 Tests and Inspections

All the equipment in the system was cleaned and tested prior to installation in accordance with the applicable codes. The system was cleaned and hydrostatically tested after installation. Welds were inspected as required by the code and all other connections checked for tightness.

Prior to startup, the system was tested with regard to flow paths, flow capacity, heat transfer capability and mechanical operability. The pumps and valves were tested for actuation at the design setpoints. Pressure, temperature and flow indicating and controlling instruments were calibrated and checked for operability.

The equipment is accessible for inspection and maintenance at all times.

## 9.8.8 General References

9.8.8.1 NRC Safety Evaluation Report Related to Amendment Number 120 to Facility Operating License No. DPR-40, December 31, 1988.

# 9.10 HEATING, VENTILATING AND AIR CONDITIONING SYSTEMS

## 9.10.1 Design Bases

The heating, ventilating and air-conditioning systems are designed to maintain a suitable environment for equipment and personnel and to protect personnel and the public from airborne radioactivity. In the discussions which follow, uncontrolled access areas are defined as those to which operating personnel have unlimited access during normal plant operation and controlled access areas are defined as those areas subject to potential release of radioactivity. The controlled access area systems (serving the containment and part of the auxiliary building) are designed to handle airborne contaminants so that offsite concentrations and in-plant doses (which are controlled by administrative procedures) are within 10 CFR Part 20 limits. The control room system is also designed to restrict the intake of airborne activity in the event of the design basis accident (DBA).

Total leak rates of 1200, 600 and 300 cc/hr from pump seals, flanges and valves respectively to the controlled access area of the auxiliary building are assumed; these leak rates constitute the basis for the rate of air change in the various areas and compartments in order that 10 CFR Part 20 requirements may be met.

The systems are designed on the basis of outside ambient air temperatures of -11°F in winter and 95°F in summer. A summer design outside air wet bulb temperature of 78°F is used for the control room air conditioning system. The design space temperatures are as follows:

Table 9.10-1 - "Design Space Temperatures"

| | Winter (°F) | Summer (°F) |
|---|---|---|
| Auxiliary Building | | |
| Controlled Access Area | 70 | 105 |
| Uncontrolled Access Area | 70 | 105 |
| Turbine Building | 65 | 105 |
| Engine Driven Auxiliary Feedwater Pump Room | 40 | 122 |
| Containment | | |
| Main Area (plant operating) | 120 | 120 |
| Main Area (cold plant and purge) | 55 | 100 |
| CEDM Enclosure (seismic skirt) | 155 | 155 |
| Nuclear Detector Wells | 110 | 110 |
| Control Room (@ 50% RH) | 78 | 78 |
| Computer Room (@ 50% RH) | 75 | 75 |
| Radioactive Waste Processing Building | | |
| General Area | 70 | 105 |
| Office Area | 72 | 78 |
| Chemistry and Radiation Protection Building | 75 | 75 |
| Office/Cafeteria Addition | 75 | 75 |

The temperatures for the controlled access area of the auxiliary building are average figures since temperature is not the sole criterion governing air change rates.

The auxiliary building, containment and control room systems are designed and constructed to Class I standards (see Appendix F).

The criteria for design of the control room air-conditioning system are that system failure will not prevent safe plant shutdown. The main control room air-conditioning system consists of two refrigeration and air handling units. Either unit can be selected for automatic operation if the running unit should fail. During periods of above normal heat load both units can be placed into operation. A VIAS will start both units. However, the third stage cooling is locked out, to minimize diesel loading, until the VIAS signal is overridden at the control room panels AI-106A and AI-106B. The two units design and connection to emergency power sources assures that safety related components in the main control room will not be adversely affected by the loss of either refrigeration or air handling unit. The air cooled condensers located on the auxiliary building roof for the refrigeration units are protected from 360 mph tornado winds. Standard Review Plan (SRP) Section 2.2.3 was used to design the air cooled condensers windscreen. The SRP criteria was met, therefore, no tornado missile shielding for the air cooled condensers is required. Reference Calculation FC06375.

The electronic equipment used in the plant safety related components can operate at 120°F continuously. The portions of the reactor protective system located in the control room were designed to operate up to 135°F and 90% relative humidity.

The heat load within the reactor protective system cabinets is low and the cabinets do not require specific air-conditioning ducting.

Temperature control of safety related instrumentation and controls outside the control room but inside the auxiliary building is maintained by the auxiliary building ventilation system. It is designed to maintain the interior of the auxiliary building below at or 105°F. If air temperature should approach 120°F in any of the rooms in the auxiliary building containing safety related instrumentation and controls, temporary supplementary cooling will be initiated. Air conditioning has been added to the switchgear rooms so that the design maximum temperatures will not be exceeded due to the separation of the redundant switchgear trains by a fire barrier. The two separate HVAC systems for the switchgear rooms are cross-tied to allow for service to either side of the fire barrier if either unit is out of service. Additional air conditioning equipment has been installed in the Counting Room area, due to the addition of temperature sensitive equipment and in the Electrical Penetration Room, due to the high heat loadings.

Temperature inside the containment is maintained below 120°F by the containment ventilating system. The maximum initial temperature assumed in the containment pressure safety analysis (Section 14.16) is 120°F.

The hydrogen purge equipment is part of the containment ventilating system, shown schematically on Figure 9.10-1. The criteria used to design this sub-system are:

a. A daily average purge rate of 25 CFM and a maximum purge rate of 250 CFM shall be possible;

b. Redundant blowers shall be supplied;

c. Control of flow rate shall be by positive means;

d. Design of the system shall recognize variation of pressure differential between the containment interior and exterior due to barometric pressure, gas accumulation, and temperature variations inside the containment;

e. Leakage from the system upstream of the filters shall be minimized;

f. The system shall be tested by periodic operation;

g. Radioactivity discharged through the system shall be measured by the stack monitoring system.

The environmental conditions specified for this system are:

Ambient temperature - 40 to 105°F
Ambient pressure - atmospheric
Radiation - 10 R/hr averaged over 40 year life
Relative humidity - 20 to 100%

The control room charcoal filter system was designed using standard review plan (SRP) 6.4 as guidance. Specifically, the following criteria was used:

a. Isolation dampers - dampers used to isolate the control room zone from adjacent zones or the outside should be leak tight. This includes the inlet and outlet dampers for each of the filter units. All isolation dampers for the control room filter system are zero leakage butterfly valves.

b. Single Failure - a single failure of an active component will not result in loss of the system's functional performance. This is accomplished by providing redundant isolation dampers, filters units, and fans. The recirculation damper is not redundant, however, the repair option delineated in Appendix A of the SRP is exercised and is reflected in the operator dose calculations. (See Section 14.15). Controls for each filter train and associated dampers are located is separate control panels. Power for each of the filter trains and associated controls is provided from separate safety related busses. The loss of a diesel generator will not result in a loss of both filter trains.

c. The control room ventilation system has a pressurization rate greater than or equal to 0.5 volume changes per hour and is subject to periodic verifications (each refueling cycle) that the makeup is ±10% of design value.

d. Credit for iodine removal for the atmosphere filtration system is determined in accordance with the guidelines of Regulatory Guide 1.52. The control room charcoal filter units meet all of the applicable RG-1.52 requirements for a 99% (elemental & organic-iodine removal efficiency.

e. Control room inlets are located considering the potential release points of radioactive material and toxic gases.

f. In accordance with ICRP-30, doses to an individual in the control room do not exceed the following for any postulated design basis accident:

   whole body (gamma) : 5 rem
   thyroid (iodine) : 50 rem
   skin (beta) : 50 rem

g. There are no chronic effects from exposure to toxic gases. Acute effects, if any, are reversible within a short period of time (several minutes) without benefit of any measures other than the use of self contained breathing apparatus.

In addition to the above, the following codes/standards apply to the control room charcoal filter system:

Overall system design is in accordance with ANSI N509 - 1980. Initial acceptance and periodic surveillance testing is in accordance with ANSI N510 - 1980. Design and testing of fire protection equipment and piping for the carbon adsorber sections of the control room charcoal filter units is in accordance with NFPA 15 and NFPA 13. Fire detection equipment is installed in accordance with NFPA 72D and 72E. Instrumentation for each filter unit is provided in accordance with SRP 6.5.1.

## 9.10.2 System Description

### 9.10.2.1 Auxiliary Building Ventilation System

The auxiliary building is ventilated and cooled with ambient outside air. It is divided into two zones for ventilation purposes, the controlled access area and the uncontrolled access area. Both systems are of the once-through, non-recirculating type using supply and exhaust fans.

Portions of the auxiliary building ventilation system are utilized by the hydrogen purge system, which is an engineered safety features system and hence, is part of the plant's engineered safeguards. The part in question is from penetrations M-30 and M-69 to the stack. For more supporting detail of components the Technical Specifications, the CQE Manual, the EEQ Manual, and Regulatory Guide 1.97 Responses should be consulted.

Controlled Access Area System

The controlled access area ventilation supply system consists of an air handling unit, containing roughing filters and preheat and reheat steam coil banks, two 50 percent capacity vane axial fans and distribution ductwork. The exhaust system consists of three 33-1/3 percent capacity vane axial fans drawing air through return ducts from each ventilated space to a common filtering unit containing high efficiency particulate air (HEPA) filters. The exhaust air is continuously monitored for radioactive contamination at the ventilation discharge duct before discharge to atmosphere. The total air throughput is 72,500 CFM and its distribution is shown on P&ID 11405-M-2.

Air is supplied to the ventilated spaces through multi-blade dampers and exhausted through ducts equipped with butterfly dampers. These dampers are pneumatically operated with remote-manual control. Each separately ventilated compartment can be isolated.

The system was designed and balanced so that the zones of highest potential radioactive contamination are at a negative pressure, relative to adjacent areas, in order to prevent outflow of air.

Charcoal filters are installed in normally bypassed ducts at the exhaust of the safety injection and spray pump rooms and the spent regenerant tank room. These filters could be remotely-manually brought onto line in the event of an accidental release of activity in these rooms during a plant emergency (Ref. 9.10-1). A Ventilation Isolation Actuation Signal (VIAS) opens the supply and return dampers for these three rooms. A differential pressure gauge is installed across each filter to provide a means of determining the condition of each filter.

A charcoal filter is also installed in a normally bypassed section of the return ductwork drawing air from the spent fuel storage pool area. Prior to spent fuel handling, the filter will be placed in service to adsorb gaseous iodines in the unlikely event of a fuel handling incident resulting in the release of large quantities of radioactivity (Section 14.18). A differential pressure gauge is installed across each filter to provide a means of determining the condition of each filter (References 9.10-1 and 9.10-9).

Additionally, temporary carbon filtration may be added to the Auxiliary Building Controlled Access ventilation system exhaust housing as required to reduce iodine releases to the environment.

The principal controls and supervisory instruments are located in the control room (see Section 7.6). The temperature instrumentation and controls are located at the air handling unit. The instrumentation is used to monitor the system exhaust temperature. The controls modulate the heating coil steam valves. In the event of a fault resulting in a low preheat coil exit temperature the controls protect the coils from condensate freezing by tripping the fans.

Uncontrolled Access Area System

The uncontrolled access area system is similar to that in the controlled access area, except that shut-off dampers are not installed, the exhaust is not filtered, and a single roof mounted centrifugal exhaust fan is employed. The total air throughput is 22,500 CFM; its distribution is shown on P&ID 11405-M-2.

The system controls and supervisory instruments are located in the control room. The temperature control system is similar to that of the controlled access area ventilation system.

9.10.2.2 Turbine Building Ventilation System

The turbine building ventilation system consists of four air handling units equipped with outside air intake louvers, recirculation air return dampers, steam heating coils with bypass provision, roll filters and four centrifugal fans which supply air to the building through ductwork. Air is exhausted from the building by fourteen roof mounted fans. The system provides once-through ventilation during the cooling season and operates with partial air recirculation during the heating season. The total fan capacity is 500,000 CFM. Additional local heating is provided by steam unit heaters.

The air handling unit and controls are located in the auxiliary building mechanical equipment room directly over the diesel-generator rooms. This room does not have direct access to the remainder of the auxiliary building, however, a door connecting rooms 81 and 82 does exist.

A ventilation system separate from the turbine building ventilation system is provided to maintain the engine driven auxiliary feedwater pump room at mild environment conditions during pump operation. The system consists of intake and exhaust grills, fire dampers, propeller fans and back draft dampers. Air from the turbine building air space is drawn into the room by two wall mounted fans and by the diesel engine as combustion air. Air is exhausted from the room at a location which minimizes recirculation. No local heating is provided in the room: components are design to withstand maximum and minimum room temperatures.

9.10.2.3 Containment Air Cooling and Ventilation Systems

The containment is served by three separate systems, the containment air cooling and filtering systems, the nuclear detector well cooling system and the containment purge system.

Containment Air Cooling and Filtering System

The system removes heat released to the containment atmosphere during normal plant operation; it is also an engineered safeguards system, and as such is fully described and discussed in Section 6.4. During normal operation filtered air is distributed to the various areas of the containment through ductwork. In an emergency the ductwork is not relied upon for air distribution and the discharge can be made through self-opening hatches.

The basic system is supplemented by forced air cooling of the control element assembly drive motors. Two vane axial fans induce an air flow through the seismic skirt which is located above the reactor pressure vessel and surrounds the lower portions of the motors. Air ducted from the main system and discharged to the region above the skirt ensures that cool air enters this subsystem.

The controls and supervisory instruments are located in the control room. The air inlet and outlet temperatures at the cooling coils, pressure differentials and the air outlet temperatures from the seismic skirt are continuously indicated. The system is normally manually operated but safeguards actuation is automatic (see Section 7.3.2).

The containment air cooling and filtering system is an engineered safety features system, and hence, is part of the plant's engineered safeguards, as defined in Section 6. For more supporting details of components the Technical Specifications, the CQE Manual, the EEQ Manual, and the Regulatory Guide 1.97 Responses should be consulted.

The system flow diagram is shown in P&ID 11405-M-1. The design data for the four air handling units are shown in Table 6.4-1

The containment air cooler units are placed in service as necessary to maintain containment temperature at the desired level during normal plant operation.

Nuclear Detector Well Cooling System

This system cools the out-of-core neutron detectors, which are located in tubes or wells in the reactor compartment annulus between the lower portion of the reactor vessel and the biological shield, and maintains the shield concrete temperature below 150°F. The system consists of two air handling units and vane axial fans installed in parallel in a closed loop. Air is ducted into the reactor compartment, where it passes up through the wells and past the detectors before recirculation to the air handling units. The closed loop arrangement limits argon-41 contamination of the containment air space. The system flow diagram is shown in P&ID 11405-M-1.

Each air handling unit contains HEPA filters and cooling coils operating on the component cooling water system. The air handling units and fans are each rated at 100 percent system design capability and can be isolated from each other so that one unit and fan normally operate with the other fan in standby. The system design data are shown in Table 9.10-3. A differential pressure gauge is installed across the VA-11 A/B filters to provide a means of determining the condition of each filter.

Table 9.10-3 - "Nuclear Detector Well Cooling System Design Data"

| | |
|---|---|
| Heat Removal Capacity, Btu/hr | 173,000 |
| Flow, CFM | 16,000 |
| Air Inlet Temperature at Unit, °F | 110 |
| Air Outlet Temperature from Unit, °F | 100 |
| Cooling Water Flow, gpm | 30 |
| Cooling Water Inlet Temperature, °F | 90 |
| Cooling Water Outlet Temperature, °F | 101.5 |

Containment Purge System

The containment purge system was designed to purge the containment by passing up to 50,000 CFM of outside air through the building. The system performs the following functions:

a. Provides means for the reduction of concentrations of radioactive particulates and noble gases in the containment; the latter cannot be reduced by the filtration equipment in the internal containment recirculation system.

b. Ventilates the building to provide a suitable environment during personnel access.

c. Allow the addition of temporary charcoal filtration to the containment purge filter housing as required to reduce iodine releases to the environment.

The purge supply system consists of two flow paths which tie into the containment recirculation ductwork.

The purge exhaust system consists of four flow paths. The two high volume flow paths each consist of an air handling unit which contains a vane axial fan and filter. The two low volume flow paths each include an axial flow fan, recirculation control valve, purge control valve and flow element. The recirculation control valves and purge control valves are used to vary the flow rate. Valves have been provided to isolate the two low volume flow paths from the high volume paths. Instrumentation, in the control room, records the flow through each flow path. Four pneumatically operated butterfly valves provide for containment isolation on the supply and return ducts at either side of the containment penetrations (see Sections 5.9 and 7.3).

The exhaust air is continuously monitored for radioactive contamination before discharge to the atmosphere through the stack (see Section 11.2.3). A bypass duct from the supply system to the monitoring station at the stack permits the system to operate at full flow capacity with a reduced air flow through the containment. In addition, remote-manually operated butterfly dampers are installed in the supply return and bypass ducts to permit modulation of the air flow. These features permit dilution and/or reduction of the containment exhaust air flow prior to environmental dispersal should the activity level in the undiluted full flow containment exhaust dispersal exceed the acceptable limit. The flow diagram is shown in P&ID 11405-M-1.

The air handling units, filter units and fans are located in the auxiliary building. The system controls and supervisory instruments are located in the control room (see Section 7.6). Flows, temperature and pressure differentials are monitored.

The pressure inside the containment will vary as a result of changes in the ambient air temperatures and leakage from air lines and operators inside the containment. The containment pressure relief line is intended to vent the containment when necessary. The flow diagram is shown on P&ID 11405-M-1.

#### 9.10.2.4 Control Room Air Conditioning System

The control room air conditioning system consists of two, air cooled split system package air conditioning units, each rated at 100 percent of the system design capacity, and supply and return ductwork. The system is designed for normal operation at 18,000 CFM total air volume with 1000 CFM of outside ventilating air makeup. The air cooled condensers for each freon refrigeration unit is located on the auxiliary building roof above Room 69. The air condenser units are protected from tornado winds with a windscreen. A waterside economizer utilizing CCW is placed in the 18,000 CFM duct to assist in control room cooling when the CCW temperature is less than 75°F.

The control room HVAC is an essential auxiliary support system and hence, is part of the plant's engineered safeguards, as defined in Section 6. For more supporting detail of components the Technical Specifications, the CQE Manual, the EEQ Manual and Regulatory Guide 1.97 Responses should be consulted.

The system conditions three individually controlled zones, the main control room area, the computer room and the office areas. In addition to the conventional space conditioning in the control room area, a part of the air supply is ducted through the control panels and instrumentation cabinets to provide direct cooling of the enclosed equipment. The system was designed to maintain a space temperature of 78°F at 50 percent maximum relative humidity. A humidifier is installed in the computer room to maintain this area at a constant relative humidity of 50 percent. The flow diagram is shown in P&ID 11405-M-97.

A thermometer is in the control room at all times for monitoring of control room temperature (Reference 9.10-11).

Two HEPA and charcoal filter assemblies (VA-64A and VA-64B), with separate booster fans (VA-63A and VA-63B) rated at 2000 CFM, are installed at the outside air makeup intake to the system. Normally this equipment is bypassed, but if a VIAS is received, one fan is automatically started, the associated filter is brought on line and the unfiltered intake is isolated. The fan that is automatically started is the fan associated with the control room air conditioning unit operating at the time of the event. The other fan and associated filter is automatically placed in standby and will start automatically if a low flow or damper misalignment signal is received. The operating filter unit filters 1000 CFM of outside air and 1000 CFM of recirculation control room air. The control room is maintained at a positive pressure while in this mode ("Filtered Air Makeup Mode") to preclude air infiltration from outside the control room envelope. This sequence will also be automatically initiated by a main steam relief valve open signal. There is a remote possibility for a simultaneous initiation of VIAS and a toxic gas accident during which toxic gas monitors will isolate the control room by closing the fresh air dampers PCV-6681A and PCV-6681B and by shutting down the control room ventilation. The control room ventilation will remain in shutdown mode and will be returned manually to the filtered mode of operation after control room operators have taken protective actions (see Section 14.23). Local differential pressure indication and remote alarms are provided across each filter unit (VA-64A and VA-64B) to provide a means of determining conditions of the filter. Remote air flow and temperature indication and alarm is provided for each unit.

The air conditioning units are located in the southwest corner of the control room. Controls for each unit are located on control room panels AI-106A and AI-106B. Toxic gas monitors at the fresh air intake (VA-65) provide for continuous measurement of fresh air to the control room in order to detect ammonia which may be released during an offsite chemical accident. The toxic gas monitors are designed to detect ammonia. Upon detection of toxic gas beyond the alarm setpoint, the control room will be isolated by automatically shutting the fresh air dampers (PCV-6681A and PCV-6681B) and by automatically shutting down the control room ventilation to preclude the infiltration of toxic gas (see Section 14.23) (References 9.10-3, 9.10-4, and 9.10-10).

### 9.10.2.5 Hydrogen Purge System

The containment hydrogen purge system is designed to provide a safe, independent, monitored, and controlled means of purging any potential accumulation of hydrogen in the containment. This prevents the hydrogen concentration in the containment from exceeding 3 percent (vol) following the extremely unlikely event of a major loss-of-coolant accident (LOCA) (Ref. 9.10-5).

The containment hydrogen purge system is an engineered safety features system and hence, is part of the plant's engineered safeguards, as defined in Section 6. For more supporting detail of components the Technical Specifications, the CQE Manual, the EEQ Manual and Regulatory Guide 1.97 Responses should be consulted.

The system consists of two purge units, each with its own 250 cfm positive displacement blower, inlet and outlet ducts, isolation valves, and two hydrogen analyzers. The purge system is manually operated and is normally isolated from the containment by locked closed valves.

The hydrogen detection system can sample the containment atmosphere at various levels via six connections. Each sample line is provided with two normally closed, remotely operated valves powered from redundant power sources. The sample is passed to a common manifold header which passes through the containment via redundant mechanical penetrations. The sample is measured with a hydrogen analyzer and returned to the containment via another mechanical penetration.

Hydrogen purge system exhaust is normally routed through HEPA and charcoal filters prior to entering the ventilation discharge duct. A normally isolated filter bypass is available to enable purging operations to continue in the unlikely event that the purge filter fails to pass flow for some reason. Radioactivity discharged by the hydrogen purge system is measured by the stack monitoring system.

### 9.10.2.6 Radioactive Waste Processing Building HVAC

The Radioactive Waste Processing Building Heating and Ventilation System consists of two 50% capacity supply air handling units, one 100% exhaust filter package, two 50% capacity exhaust fans, associated dampers, accessories and controls. Each of the supply air handling units consists of a fan, filters and a supply heating coil. The ductwork on the downstream side of each air handling unit and fan has a backdraft damper. There is a pneumatic operated isolation damper upstream of each air handling unit, each exhaust fan, and the HEPA filter package. The exhaust air filter package can be isolated by the isolation dampers upstream of the Filter package and the two isolation dampers downstream of the package, upstream of the exhaust Fans. The system supplies filtered heating and ventilation to limit the summer building temperature to 105°F maximum and the winter building temperature to 70°F minimum. Controls for the system are pneumatic and electric.

The supply and exhaust fans are controlled by handswitch's on the local HVAC control panel. In addition to automatic trip on motor overload, the fans are interlocked such that each exhaust fan always leads its respective supply fan on start-up and lags the supply fan on shutdown. Therefore, if an exhaust fan trips, the associated supply fan will also trip, to prevent pressurization of the building. Exhaust from the building passes through HEPA filters and a radiation monitor samples the exhaust before discharge to the atmosphere.

Radioactive Waste Processing Building Office Area HVAC System

The Radioactive Waste Processing Building Office Area HVAC consists of 100% packaged rooftop air conditioner with electric heating coil and filter with supply and return ductwork and ductwork accessories. This system supplies filtered, heated, and cooled air to maintain the office area temperature of 75°F±3° (78°F Summer/72°F Winter). The package roof top unit shall include controls which are electric and integral to the unit by a room thermostat, located in Room 511.

9.10.2.7 Chemistry and Radiation Protection (CARP) Building HVAC Systems

The HVAC for the CARP Building is subdivided into the Laboratory Area, Office Area, OPPD Locker Rooms, and Contractor Locker Rooms HVAC systems. All cooling coils are direct expansion, all heating coils are electric and all condensers are air-cooled. The HVAC systems are designed to maintain the CARP Building at 75 ± 3°F.

The Laboratory Area HVAC System consists of a commercial quality, penthouse, multizone, air handling unit with a remote condenser for supply air, and a Regulatory Guide 1.140 HEPA Filter Package for exhaust air. The Laboratory exhaust ties into the Radioactive Waste Processing Building exhaust where it is monitored prior to release to the atmosphere. The Chemistry Counting Room supply is filtered through a HEPA Filter Package. The areas served by the Laboratory HVAC system are maintained at a negative pressure with respect to adjacent areas in the CARP Building. The Chemistry Counting Room and the Computer Room are maintained at a positive pressure with respect to adjacent areas served by the Laboratory HVAC System.

The Office Area HVAC System consists of a commercial quality, package, roof-top, variable air volume unit. The office area is maintained at a positive pressure with respect to the adjacent Laboratory Area, Locker Room Areas, and Auxiliary Building Areas.

The OPPD and Contractor Locker Rooms HVAC Systems consist of commercial quality, packaged, roof-top, constant volume units. Exhaust fans are provided for the toilet and shower areas. The Locker Room areas are maintained at a negative pressure with respect to the adjacent office areas.

9.10.2.8 Office/Cafeteria Addition HVAC Systems

The HVAC for the Office/Cafeteria Addition is subdivided into the Cafeteria Area and Office Area HVAC systems. All cooling coils are direct expansion, all heating coils are electric, and all condensers are air cooled. The HVAC systems are designed to maintain the Office/Cafeteria Addition at 75 ± 3°F.

The Cafeteria Area HVAC system consists of a commercial quality, single zone, air handling unit with filter and mixing sections, and remote condensing unit for supply air. Exhaust fans are provided for exhausting at dishwashing and cooking/frying areas. The cafeteria area is maintained at a positive pressure with respect to the adjacent CARP Building.

The Office Area HVAC System consists of a commercial quality, single zone, air handling unit with filter and air mixing sections and remote condensing unit for supply air. An exhaust fan is provided to exhaust the toilet and janitor rooms. The Office Area is maintained at a positive pressure with respect to the adjacent CARP Building.

## 9.10.3 System Components

### 9.10.3.1 Auxiliary Building Ventilation System

The air handling supply units in the controlled and uncontrolled access area systems are of similar design. The steam heating coils are commercial finned tube units and the roughing filters are the automatically advanced roll type. This equipment is installed in galvanized steel housings with appropriate access provisions.

The supply and exhaust fan data are shown in Table 9.10-4.

Table 9.10-4 - "Auxiliary Building Fan Data"

| | Controlled Access Area Supply | Controlled Access Area Exhaust | Uncontrolled Access Area Supply | Uncontrolled Access Area Exhaust |
|---|---|---|---|---|
| Item No's, VA- | 35A&B | 40A, B & C | 45A&B | 41 |
| Number Installed | 2 | 3 | 2 | 1 |
| Design Air Flow, CFM per fan | 36,250 | 24,200 | 13,000 | 20,000 |
| Motor Rating, HP per fan | 60 | 60 | 10 | 20 |

The controlled access area exhaust filter unit consists of a leak-tight galvanized steel housing containing three HEPA filter compartments each of which can be isolated and is separately accessible. These filters are similar to those used in the containment air cooling and filtering system as discussed in Section 6.4.3 but differ in that they use replaceable prefilter elements ahead of the HEPA elements as opposed to mist eliminators.

The charcoal filters in the bypass ducts at the exhausts from the emergency safeguards pump and piping compartments and the spent fuel pool area are of pleated design with one inch thick adsorber beds. The activated charcoal is similar to that in the containment air cooling and filtering system filters as described in Section 6.4.3. The filter design ensures that there is no bypassing around the beds. A differential pressure gauge is installed across each filter to provide a means of determining condition of each filter.

The controlled access area exhaust ductwork is welded and flanged and is leak tight. All other ductwork is of conventional design and fabrication. The controlled access area supply dampers are multi-blade design with blade seals for tight shut off. The exhaust system butterfly valves provide "bubble-tight" shut-off to effect complete compartment exhaust isolation.

The ventilation discharge duct is a cylindrical steel structure located close to, and laterally supported from the containment wall; it terminates close to the top of the containment stressing gallery.

9.10.3.2 Turbine Building Ventilation System

The turbine building main ventilation equipment is of standard, commercial design. The fans are centrifugal machines; data are shown in Table 9.10-5.

Table 9.10-5 - "Turbine Building Fan Data"

| | Supply | Exhaust |
|---|---|---|
| Item No's VA- | 151A thru D | 158A thru P |
| Number Installed | 4 | 14 |
| Air Flow, CFM per fan | 125,000 | 35,715 |
| Static Pressure Rise, in. $H_2O$ | 3.25 | 7.5 |
| Motor Rating, HP per fan | 100 | 7.5 |

### 9.10.3.3 Containment Air Cooling and Ventilation Systems

The containment air recirculation system air handling components are discussed in Section 6.4.3. The HEPA filters used in the nuclear detector well cooling system are similar to those of the above system.

The nuclear detector well cooling coils are the standard drainable, finned tube type. The air handling unit housings are of leak tight galvanized steel construction.

The purge supply system air handling units are similar in design to those already described for the auxiliary building systems.

The two purge system exhaust filter units are similar to the auxiliary building controlled access area units.

The nuclear detector well and purge exhaust ductwork is welded and flanged and is leak tight. Elsewhere, ductwork is of conventional design and fabrication except that duct sections in the containment are flanged to permit removal should cleaning and decontamination ever become necessary. The containment purge isolation butterfly valves are designed for a maximum leak rate of 0.01 SCF per hour at the DBA conditions of 60 psig, 288°F and 100 percent humidity.

Containment system fans are pre-set, adjustable pitch, air-over-motor, vane axial machines. The recirculation and cooling system main fans are discussed in Section 6.4.3. Other fan data are shown in Table 9.10-6.

Table 9.10-6 - "Containment Air Cooling Systems, Fan Data"

| | CEDM Cooling | Nuclear Detector Well | Purge Supply | Purge Exhaust | | |
|---|---|---|---|---|---|---|
| Item No's VA- | 2A&B | 12A&B | 24A&B | 32A&B | 76 | 77 |
| Number Installed | 2 | 2 | 2 | 2 | 1 | 1 |
| Air Flow, CFM per fan | 10,000 | 16,000 | 25,000 | 25,000 | 0-10,000 | 0-2500 |
| Static Pressure Rise, in. $H_20$ | 3.3 | 6.9 | 6.8 | 6.9 | 2.5 | 3.0 |
| Motor Rating, HP per fan | 15 | 40 | 40 | 40 | 7.5 | 3.0 |

9.10.3.4 Control Room Air Conditioning System

The air conditioning units are standard machines with hermetic compressors and air cooled condensers. A water side economizer utilizing CCW is required to provide the needed control room cooling when the ambient temperature is below 0°F (Reference Calculation FC06311). Ductwork was designed to commercial standards.

The emergency intake HEPA and charcoal filters are installed in air tight housings normally isolated at either end with butterfly type tight shut-off dampers. The HEPA filters are similar to those previously described for the other systems. The charcoal filters consist of V-bed units containing two inch deep beds of activated charcoal which is similar to that in the containment air cooling and filtering system as described in Section 6.4.3. The filter design ensures that there is no bypassing around the beds. The filter booster fans are centrifugal machines with a capacity of 2000 CFM. A heater is provided in each filter unit to maintain maximum air stream relative humidity below 70%.

### 9.10.3.5 Radioactive Waste Processing Building HVAC Systems

The make-up air handling units are of the central station packaged type consisting of fan, heater, and filter sections mounted together in a common housing on a common base frame. The exhaust fans are centrifugal type with radial blade wheels mounted on a fan/motor isolation base. The exhaust filter package is designed to the requirements of ANSI N-509, 1980 and provides HEPA Filtration of the building exhaust air flow, which is also monitored.

Table 9.10-7 - "Radioactive Waste Processing Building Fan Data"

| | Make-up Air Handling Units | Process Exhaust Fans | Offices HVAC Unit | Toilet Exhaust Fan |
|---|---|---|---|---|
| Item Number VA | 600 A+B | 30 A+B | 602 | 604 |
| Number Installed | 2 | 2 | 1 | 1 |
| Design Air Flow Rate Per Fan (CFM) | 7375 | 8350 | 2450 | 150 |
| Design Total Pressure Rise (Inches $H_20$) | 4.0 | 16.8 | 1.0 | .25 |

### 9.10.3.6 Chemistry and Radiation Protection (CARP) Building HVAC Systems

The Laboratory Area HVAC Supply System consists of one 100% multizone air handling unit, nine electric heating coils mounted in the zone supply ducts, two 50% packaged electronic humidifiers, and a HEPA filter package located in the Chemistry Counting Room supply duct. The air handler consists of a supply fan, filter section, electric heating coil, direct expansion cooling coil, outdoor air intake damper and multizone dampers. The condensing unit consists of two 50% compressors, condensing coils and condenser fans.

The Laboratory Area exhaust system consists of one 100% Regulatory Guide 1.140 filter package, an exhaust fan, inlet and outlet isolation dampers, and welded stainless steel ductwork. The filter package consists of prefilters and HEPA filters.

The Office Area HVAC System consists of one 100% variable air volume air handling unit, a packaged electronic humidifier, and 12 variable air volume terminal control units with electric heat. The air handling unit consists of a fan, filter section, electric heating coil, direct expansion cooling coil, compressor, condenser section, return air and maximum outside air modulation dampers, and exhaust fan section.

The OPPD and Contractor Locker Room HVAC system consist of one 100% constant volume air handling unit and an electric heating coil mounted in the Women's Locker Room supply duct. The air handling unit consists of a fan, filter section, minimum outside air damper, exhaust air, return air and maximum outside air modulating dampers and an exhaust fan section. The systems also include exhaust fans for the toilet and shower areas.

Table 9.10-8 - "Carp Building-Fan Data"

| | Laboratory Air Handling Unit | Process Exhaust Fan | Office Area HVAC | Contractor Locker Room HVAC | OPPD Locker Room HVAC |
|---|---|---|---|---|---|
| Item Number | | | | | |
| VA | 652 | 651 | 636 | 632 | 628 |
| Number Installed | 1 | 1 | 1 | 1 | 1 |
| Design Air Flowrate (action) | 9800 | 12000 | 9000 | 4000 | 8000 |
| Design Total Pressure Rise (in. $H_20$) | 5 | 13 | 2 | 1 | 1.74 |
| Fan hp. | 20 | 40 | 3 | 3 | 3 |
| Item Number | | | | | |
| VA | 629 | 630 | 633 | 673 | 634 |
| Number Installed | 1 | 1 | 1 | 1 | 1 |
| Design Air Flowrate | 1300 | 640 | 945 | 1880 | 695 |
| Fan hp. | 1/2 | 1/4 | 1/3 | 3/4 | 1/4 |

### 9.10.3.7 Office/Cafeteria Addition HVAC Systems

The Cafeteria Area HVAC System Consists of one 100% constant volume single zone air handling unit, one duct mounted electric reheat coil, one electric propeller type unit heater, one electric baseboard radiator, and two roof mounted exhaust fans. The air handling unit consists of a supply fan and direct expansion cooling coil section, electric heating coil section, filter section, and air mixing section with outdoor and return air dampers. The condensing unit consists of three 33% compressors, condenser coils, and fans.

The Office Area HVAC System consists of one 100% constant volume single zone air handling unit, two duct mounted electric reheat coils, two electric, baseboard radiation and one roof mounted exhaust fan. The air handling unit consists of a supply fan and direct expansion cooling coil section, electric heating coil section, filter section and air mixing section with outdoor and return air dampers. The condensing unit consists of two 50% compressors, condenser coils, and fans.

Table 9.10-9 - "Office/Cafeteria Fan Data"

| | Cafeteria HVAC | Office Area HVAC | Restroom Exhaust Fan | Dishwasher Exhaust Fan | Kitchen Exhaust Fan |
|---|---|---|---|---|---|
| Item Numbers | | | | | |
| VA | 702 | 703 | 709 | 710 | 711 |
| Number Installed | 1 | 1 | 1 | 1 | 1 |
| Design Air Flowrate | 5200 | 5600 | 600 | 650 | 2500 |
| Design Total Pressure Rise | 3.89 | 3.71 | .625 | .625 | .625 |
| Fan hp | 7.5 | 7.5 | 1/2 | 1/2 | 1/2 |

## 9.10.4 System Operation

### 9.10.4.1 Auxiliary Building Ventilation System

Auxiliary Building Controlled Access Area System

The system operates continuously and once started, normally requires minimal supervision. If high discharge radiation activity is alarmed several options are open to the operator:

a. If the compartment containing the source of activity is known, then this compartment can be individually isolated by closing the dampers;

b. Compartments and areas can be isolated and the dampers sequentially opened to identify the activity source;

c. The system can be operated in conjunction with the containment purge supply and bypass system to reduce the discharge concentrations by dilution.

Should the containment be undergoing a purge and the stack monitor indicates high radioactivity, the radiation monitoring cabinet permits samples of the containment atmosphere and the auxiliary building exhaust to be independently monitored. This allows the building in which the activity source is present to be identified and the appropriate action can be taken.

In the event of leakage in any of the safeguards pump rooms during post-DBA recirculation cooling, high radiation at the exhaust stack might be alarmed. If continued operation with leakage is possible the compartment affected cannot be isolated since the equipment would overheat. In this case the bypass charcoal filter in the compartment exhaust duct is brought on line to pass the exhaust through the filter. This subject is also discussed in Section 6.2.6.3. An EOP/AOP Attachment provides instructions for restoring Auxiliary Building Controlled Area ventilation after an accident. The purpose of that attachment is to restore forced air flow through the SI pump rooms for equipment cooling in the event of a DBA coincident with a loss of offsite power. An emergency key operated bypass switch allows the supply and exhaust fans to remain in operation under off-normal conditions if a spurious fan trip occurred (such as a smoke detector, freezestat, or duct pressure alarm).

Auxiliary Building Uncontrolled Access Area System

The system operates continuously and requires minimal supervision. There are no special operating procedures either during normal operation or in any emergency situation.

9.10.4.2 Turbine Building Ventilation System

This system with exception of the engine driven auxiliary feedwater pump room also operates continuously and requires minimal supervision. There are no special operating procedures either during normal operation or in any emergency situation.

The ventilation system for the engine driven auxiliary pump room operates automatically when the engine operates. When the engine starts, one of the two fans is energized. If the temperature in the room increases to above 105°F, the second fan is energized. If normal electrical power to the fans is unavailable, the fan's load automatically transfers to the integral engine driven auxiliary generator.

9.10.4.3 Containment Air Cooling and Ventilation Systems

Containment Air Cooling and Filtering System

The system operates continuously during reactor operation. It may also be operated during shutdown periods to supplement the purge system by providing additional air cooling and filtration. This mode is not a design requirement however.

At normal design conditions, operation of either both the cooling and filtering units or one of the cooling and filtering units and both cooling units is required as discussed in Section 9.10.2.3. However, during the winter months the cooling system water is at a temperature significantly below the design temperature, having the effect of increasing the cooling capacity of the coil units. Also, the lower ambient outside temperatures result in increased heat losses from the containment. Under these circumstances it is probable that the system could be operated with less than the design number of units on line. However, such partial system operation will only be undertaken once it has been demonstrated that equipment relying upon air cooling, in particular the reactor coolant pump motors, are not starved of air.

The stators of these motors are instrumented to provide temperature indication with appropriate high temperature alarms.

Nuclear Detector Well Cooling System

The system operates continuously during reactor operation with one air handling unit in operation and the other on standby. During reactor shutdown periods the system is normally shut down but it can be used to provide ventilation when maintenance is being carried out in the nuclear detector well area.

Containment Purge System

The purge system is operated under the following circumstances:

a. During reactor shutdown periods;

b. In the containment bypass mode, to provide dilution of the auxiliary building controlled access area ventilation exhaust, should this ever be required.

If the system is operating and the emergency safeguards are initiated or the discharge duct monitor indicates high radioactivity, the purge system duct dampers at the containment penetrations are automatically closed and the fan motors are tripped (See Sections 7.3.2.6 and 11.2.3.2) (References 9.10-6, 9.10-7 and 9.10-8).

### 9.10.4.4 Control Room Air-Conditioning System

The system normally operates continuously with one air-conditioning unit operating and the other on standby, but both units can operate simultaneously if heat load dictates. A VIAS will allow up to two stages of the three stage refrigeration compressor to operate, to limit electric diesel generator loading. There is an override manual control on this VIAS to allow three stage compressor operation. VIAS will also close the CCW inlet and outlet valves on the economizers. There is one mode of operation at normal plant conditions:

a. With 1000 CFM of outside make-up, 17,000 CFM recirculated and the cooling coils operable. The system is under automatic control from the space thermostats. The air intake HEPA and charcoal filter units are bypassed.

   This mode of operation can be initiated from the control room. A selector switch for each unit also provides for the following operating conditions.

b. As in (a) above except that one of the HEPA and charcoal filter units is brought on-line, the associated booster fan is started and the normal air intake is closed. The second filter unit is maintained in a standby condition. The toilet exhaust fan is tripped and the associated damper is closed.

c. 18,000 CFM of air is internally circulated with all outside dampers closed. The system is under automatic control from the space thermostats.

d. All outside dampers are closed and the control room ventilation is shutdown to preclude the infiltration of ammonia toxic gas during a toxic gas release accident.

Condition (b) is the design mode of operation in the event of the DBA. The system is automatically brought to this condition by the ventilation isolation actuation signal (see Section 7.3.2.6). Following a DBA, it is still possible to select condition (c) by operation of the mode selector switch.

Condition (d) is the design mode of operation in the event of a toxic gas release accident. The system is automatically brought to this condition via the alarm signal from the ammonia toxic gas monitors. Following a toxic gas accident it is still possible to select position (a), (b), or (c) by using the toxic gas isolation override switch and the mode selector switch for the control room ventilation systems (see Section 14.23).

#### 9.10.4.5 Radioactive Waste Processing Building HVAC Systems

This system operates continuously and requires minimal supervision. Control system design provides interlocking to prevent operation of building supply system without associated exhaust fans on. The system is designed to allow operation at 50% capacity to allow for energy savings during periods of low building use.

#### 9.10.4.6 Chemistry and Radiation Protection (CARP) Building HVAC Systems

The CARP Building HVAC Systems operate continuously and require minimal supervision. Controls for the systems are electric/ electronic.

#### 9.10.4.7 Office/Cafeteria Addition HVAC Systems

The Office/Cafeteria Addition HVAC Systems operate continuously and require minimal supervision. Controls for the systems are electric/ electronic.

### 9.10.5 Design Evaluation

The heating, ventilation and air-conditioning systems provide a suitable environment for equipment and personnel over a design range of ambient outside temperatures from -11°F to 95°F (dry bulb) and 78°F (wet bulb). In those areas where airborne radioactivity could constitute a hazard, the reduction of this activity is the prime design consideration. Administrative procedures ensure that doses to personnel in these areas are within 10 CFR Part 20 limits during normal plant operation. The systems have the capability of limiting off-site release of airborne contaminants to concentrations below those specified in 10 CFR Part 20 by filtration, dilution and, if necessary, isolation.

The auxiliary building, containment and control room systems are designed to survive the seismic loadings imposed during the maximum hypothetical earthquake without damage or any change or loss of function.

## 9.10.6 Availability and Reliability

The heating, ventilating and air-conditioning equipment is, as a minimum, in accordance with accepted industrial standards and was designed to operate continuously for extended periods without attention.

The nuclear detector well and control room systems are provided with 100 percent standby capacity. The containment air cooling and filtering system is a multi-unit arrangement with 50 percent excess installed capacity, and since it is also an emergency safeguards system (see Section 6.4), it was designed and fabricated to standards which reflect the importance of the safeguards function. Where standby equipment is provided, operation will be on an alternating basis to provide assurance of operability.

The purge, auxiliary and turbine building systems have multiple fans so that in the event of fan failure, the systems can still function but at reduced capacity.

The auxiliary building systems are shut down during the short and infrequent periods when the intake filter rolls are replaced. The arrangement of the auxiliary building controlled access area exhaust HEPA filters permits one-third of the filtration capacity to be replaced without disturbing the remainder. The system operates at slightly reduced capacity during filter replacement. Purge system filter replacement can be scheduled for the periods when this system is shut down.

The systems are dependent upon the electrical and component cooling water systems except for control room HVAC refrigeration system which are discussed in Sections 8 and 9.7 respectively. (The control room HVAC system utilizes CCW for economizer coils only.)

The control element drive mechanism motors are cooled by a combination of the main air handling units and the CEDM cooling fans. The former deliver cooled air to the area of the drive motors and the latter ensure that air is withdrawn from the drive motor region downwards through the seismic skirt. The function of the CEDM cooling fans is to remove heat from the drive housings, thus lowering temperatures inside the mechanisms and reducing wear, and to keep instrumentation cables cool. Neither function is necessary for the continued short term operation of the plant. There is concern over mixing of the cool air being supplied to the drive motors and hot air rising from the housings when the fans are not operating.

Continued short term operation of the plant, so far as cooling of the drive motors is concerned, depends only on availability of the main air handling units. These units must be in operation to cool other loads in the plant, e.g., reactor coolant pump motors. Continued operation of the plant without any main air handling units is prohibited for multiple reasons. The main air handling units are very reliable units and redundancy is available.

The neutron detector well cooling units serve the following two functions:

a. Maintain concrete temperatures in the concrete shielding surrounding the reactor vessel below 150°F.

b. Maintain neutron detector temperature below 300°F.

The neutron detector cooling system comprises two independent cooling units, either of which can handle the required cooling load. It is considered unlikely that both would be out of service at the same time.

Thermal detectors are buried at strategic locations in the concrete. If both cooling units should be out of service simultaneously, the operator can use this instrumentation to evaluate how rapidly the reactor must be cooled down to avoid concrete damage. Since the neutron flux is high at the location of the sensors, a loss of cooling units test was run early in life to evaluate the required rapidity of shutdown. This test was run after criticality since the major source of heat in the concrete is radiation absorption.

If concrete is heated above 150°F, it is likely to suffer a reduction in strength. The magnitude of the reduction would be dependent on the rate of temperature rise, the maximum temperature attained and the duration of the elevated temperature. The limit of 150°F is consistent with the requirements of ACI-318-63.

This loss of cooling unit test provided data to evaluate temperature at the neutron instrumentation. Permanent temperature measuring devices were not installed at this location since the neutron flux is too high. The neutron instruments have been shown by test to be suitable for temperatures of 300°F and less. Above this level, the signal deteriorates.

The Radioactive Waste Processing Building Heating and Ventilating System has two 50% capacity exhaust fans and two 50% capacity supply fans so that the system can still operate at reduced capacity in the event of a fan failure.

## 9.10.7 Tests and Inspections

All HEPA and charcoal filters were subject to performance tests prior to delivery. Testing procedures followed those outlined in Section 6.4.7. Heating and cooling coils were pressure tested at the manufacturer's shop.

All leak-tight ductwork and equipment housings were pressure tested with air at 0.5 psig after installation and all joints were examined for leaks using soap solution. The testing of the purge system containment isolation valves is discussed in Section 5.9.6.

After installation the system was tested with regard to flow paths, flow capacities, heating and cooling capabilities, mechanical operability and filtration efficiency. Dampers and the pumps and valves of associated systems were tested for operation at the proper setpoints. Controls, instruments and alarms were checked for operability and adequacy of limits.

The testing and inspection of the containment air cooling and filtering system equipment is discussed in Section 6.4.7. The HEPA and charcoal filters in the auxiliary building, purge and nuclear detector well systems are periodically inspected or replaced. The control room filters can be tested or replaced during plant operation.

Equipment outside the containment is accessible for test and inspection during plant operation. Access to the containment is restricted during reactor operation, but is sufficient to allow for the inspection of key components.

## 9.10.8 Specific References

9.10-1 Safety Evaluation Report Supporting Amendment Number 52 to the FCS Technical Specifications, October 14, 1980

9.10-2 Deleted

9.10-3 Safety Evaluation Report Supporting Amendment Number 87 to the FCS Technical Specifications, April 29, 1985

9.10-4 Safety Evaluation Report Supporting Amendment Number 107 to the FCS Technical Specifications, March 30, 1987

9.10-5 Safety Evaluation Report Supporting Amendment Number 138 to the FCS Technical Specifications, March 19, 1991

9.10-6 Safety Evaluation Report Supporting Amendment Number 68 to the FCS Technical Specifications, February 24, 1983

9.10-7 Safety Evaluation Report Related to the Mechanical Operability of Purge/Vent Valves, February 24, 1982 (Cartridge 923, Frame 1771)

9.10-8 Safety Evaluation Report Related to Minimum Containment Pressure Setpoint, July 28, 1981 (Cartridge 997, Frame 1823)

9.10-9 Safety Evaluation Report Supporting Amendment Number 154 to the FCS Technical Specifications, August 10, 1993

9.10-10 Safety Evaluation Report Supporting Amendment Number 183 to the FCS Technical Specifications, January 28, 1998

9.10-11 NRC Amendment 188 to Technical Specifications, December 31, 1998.

## 9.10.9 General References

9.10.9.1 Safety Evaluation Report Supporting Amendment Number 128 to the FCS Technical Specifications, April 12, 1990

9.10.9.2 Safety Evaluation Report Supporting Amendment Number 15 to the FCS Technical Specifications, September 3, 1976

9.10.9.3 NRC Generic Letter 92-16, NUREG-0737 Related Items, October 27, 1982

9.10.9.4 NRC IE Bulletin Number 80-03, Loss of Charcoal from Standard Type II Tray Absorber Cells, February 6, 1980

9.10.9.5 Safety Evaluation Report Supporting Amendment Number 67 to the FCS Technical Specifications, February 2, 1990

9.10.9.6 Safety Evaluation Report Supporting Amendment Number 130 to the FCS Technical Specifications, May 23, 1983

## 9.11 FIRE PROTECTION SYSTEM

### 9.11.1 Design Bases

The objective of the fire protection program is to minimize both the probability and consequences of fire. The fire protection program for the Fort Calhoun Station consists of design features, personnel training, operating procedures, fire protection systems and fire fighting equipment provided to reduce the adverse effect of fires on structures, systems, and components, such that in the event of a fire the plant can be safely shut down. This is accomplished by using a defense-in-depth approach which consists of:

1. Prevention of fires through administrative control of fire hazards,
2. Quick detection and suppression of fires when they have occurred, and
3. Implementation of design provisions to provide adequate protection of safe shutdown functions.

The design basis of the fire protection systems includes commitment to APCSB Branch Technical Position 9.5-1, Appendix A, May 1, 1976 and 10 CFR 50, Appendix R, Items, III.G, III.J, and III.O. The Updated Fire Hazards Analysis documents Fire Protection Program Comparison Matrix to BTP 9.5-1 and Appendix R, Sections III G, J, and O requirements. The fire protection program reporting requirements are provided in Technical Specifications Section 5.0.

Structures, systems, and components are designed and located to minimize, consistent with other fire safety requirements, the probability and effects of fire and explosions.

The plant design has been reviewed and design provisions have been included to provide protection of systems required for safe shutdown by suppression systems, physical barriers and/or spatial separation. Combustibles have been identified and minimized as much as practical. Additionally, provisions have been made for early detection of possible fires, as well as for suppression systems where combustible materials warrant.

National Fire Protection Association (NFPA) codes were used as guidelines in the design of passive fire protection features (e.g., fire doors, dampers, and walls), active fire protection systems (e.g., fire suppression and detection systems), and in the development of administrative controls of fire hazards. Unique situations and configurations arise in nuclear power plants that are not specifically addressed in NFPA codes. These require departures from strict adherence to NFPA code requirements based on sound engineering principles.

The requirements of the Nuclear Energy Property Insurance Association (NEPIA now American Nuclear Insurers [ANI]), which were discussed in a series of conferences between the Association, OPPD and the architect-engineer, were followed in the design of these systems. Generally, subsequent modifications have been made in accordance with guidance contained in APCSB Branch Technical Position 9.5.1., Appendix A., May 1, 1976, and ANI Fire/All Risk Guidelines.

The fire extinguishing system designs are based on the assumption that outside help will not be immediately available to assist in fighting fires; therefore, the systems are independent of aids external to the plant. The water supply is drawn from the Missouri River. One of the fire pumps is diesel engine driven and is therefore independent of on and off-site power.

Fire barrier walls enclosing separate fire areas utilize fire resistive construction. Penetrations in fire barrier walls are protected by doors, dampers, and penetration seals with fire resistance ratings commensurate with the hazards in the area. Fire rated barrier systems equate to, or are bounded by, configurations that have been tested according to the ASTM E-119 "Standard Time Temperature Curve." Exceptions in the ratings of protective systems for openings in fire barrier walls have been identified, analyzed and determined to be acceptable. (See Safety Evaluation Report, April 8, 1982, and revisions dated August 12, 1982, July 3, 1985, November 5, 1985 and July 1, 1986 and NRC letter to OPPD granting exemptions from 10 CFR 50 Appendix R dated July 3, 1985, also the Updated Fire Hazards Analysis).

### 9.11.2 Fire Brigade Staffing

A fire brigade consisting of 5 members is maintained on site at all times. The fire brigade does not include the minimum shift crew necessary for safe shutdown of the unit (2 members). The fire brigade composition may be less than the minimum requirements for a period of time not to exceed 2 hours in order to accommodate unexpected absence of fire brigade members. Immediate action shall be taken to restore the fire brigade to within the minimum requirements.

### 9.11.3 Fire Brigade Training

A training program for the fire brigade is maintained under the Manager-Training which meets or exceeds the requirements of Section 27 of NFPA Code-1975, except that the meeting frequency may be quarterly.

### 9.11.4 Component and System Design and Operation

#### 9.11.4.1 General Description

The overall fire protection system provides means for detecting, alarming, isolating and suppressing plant fires. The system is divided into the following subsystems:

a. The Fire Detection and Alarm System; this is an instrumentation system which alerts control room operators of a fire and indicates its location.

b. The Fire Suppression System; this includes fire fighting equipment such as automatic sprinklers, deluge systems, portable fire extinguisher, automatic Halon fire extinguishing systems, standpipe hose systems, and outside fire hydrants.

c. The features of plant design and construction which contribute to the separation of fire hazards into zones and fire areas.

### 9.11.4.2 Fire Detection and Alarm System

The Fort Calhoun Station fire detection system consists of extensive fire detectors in safety-related areas, strategically located manual fire alarm pull stations, and numerous local annunciator panels located throughout the plant and general site buildings. Fire and smoke detectors used in the plant include ionization detectors, photoelectric detectors, heat detectors, infrared flame detectors, and smoke detectors in ducts.

Detectors are strategically positioned throughout the facility. Most of the detectors are placed at ceiling level in each room. In large rooms multiple detectors are employed. Ionization detectors are located inside ventilation ducts since ducts are paths for spreading products of combustion. Battery powered smoke detectors have been installed in safety related cabinets in the control room. Thermal detectors are provided in the adsorber sections of the control room outside air filter units.

Fire detectors in the general plant area are arranged to sound an alarm on the fire alarm annunciator panel in the control room. This panel also has indicating lights to show the specific fire detection zone involved.

The fire detection system within the containment building includes specific coverage for fires in the reactor coolant pump compartments. One ionization and one flame detector are strategically located in each of the four compartments to give adequate fire detection. If a fire is detected inside the containment, it will be extinguished using portable fire fighting equipment.

### 9.11.4.3 Fire Suppression System

The Fire Suppression System consists of several sub-systems including the Fire Suppression Water Supply and Distribution System, Hydrants, Automatic Water, Carbon Dioxide and Halon Suppression Systems, Manual Hose Stations and Portable Extinguishers.

The fire protection water supply system (see P&ID 11405-M-266) has two vertical turbine type fire pumps, one electric motor driven and one diesel engine driven, each rated for 2000 gpm at 125 psig. Pressurization of supply piping is provided by means of jockey pump. If pressure drops below predetermined setpoints, the fire pumps automatically start. The fire pumps can also be started remote-manually. Both pumps deliver screened and strained Missouri River water to the plant's underground water distribution system, which in turn supplies the plant's automatic water fire suppression systems, interior hose stations, and fire hydrants in the yard.

An independent underground looped yard main system capable of delivering sprinkler flow plus adequate hose flow to support manual fire fighting for a single fire is provided for the fire protection system. The yard loop is constructed of twelve-inch and ten-inch transite and cast (ductile) iron pipe with cement lining. Freezing of the fire water distribution system is prevented by burying the piping below the frost line and by routing indoor piping through heated areas. The system is provided with various types of sectionalizing valves to facilitate the isolation of portions of the system for maintenance or repairs, without interrupting the supply to the remaining system.

A secondary water supply is available from a valved cross-tie to the screen wash pump discharge header.

Automatic sprinkler and water spray protection is provided in several areas of the plant containing combustible liquids, as well as specific areas containing safety-related systems, equipment, and components. The fire extinguishing systems design is based on the assumption that outside help will not be immediately available to assist in fighting fires. They are, therefore, independent of aids external to the plant.

Four safety related plant areas are provided with automatic Halon 1301 extinguishing systems. Guidelines established in NFPA 12A were generally followed in the system design and installation.

Hose stations are located in the Auxiliary Building, the Intake Structure, the Turbine Building, Maintenance Shop, Main Warehouse, CARP Building, Office/Cafeteria addition, and Radioactive Waste Processing Building.

The indoor standpipe and hose systems consist of water distribution systems to various hose stations located so that adjacent areas can be reached in case of fire. A detailed listing of the Inside Hose Stations is provided in the Updated Fire Hazards Analysis.

Fire hydrants are located around the perimeter of the plant. The hydrants are fed by the yard loop. Inside of the Protected Area outdoor fire hydrants are equipped with hose houses which contain the hose, nozzles, and tools. Fire fighting equipment located in hydrant hose houses is readily available to the plant fire brigade. Hydrants are located approximately 50 feet from the structure and are placed approximately every 300 feet along the fire ring main around the plant buildings. Additional fire hydrants are located outside of the Protected Area North and East of the Main Warehouse. These hydrants are outside of the Security Fence and are not equipped with hose houses.

Portable fire extinguishers are provided (generally in accordance with NFPA 10 - Standard for Portable Fire Extinguishers) throughout the Facility. Fire Extinguishers are of the dry chemical, $CO_2$, Halon and AFFF type. Extinguisher type has been matched to the hazard in the area.

The major fire extinguishing system components for inside the protected area are described below.

Table 9.11-1 - "Extinguishing System Major Component Data"

| PUMPS No. of Units | Name | Type | Unit Capacity |
|---|---|---|---|
| 1 | Motor Driven Fire Pump (Item No. FP-1A) | Turbine | 2000 gpm @ 125psid |
| 1 | Diesel Driven Fire Pump (Item No. FP-1B) | Turbine | 2000 gpm @ 125psid |
| 1 | Jockey Pump (Item No. FP-5) | Centrifugal | 25 gpm @ 130psid |
| **HOSE STATIONS No. of Units** | **Name** | **Type** | **Description** |
| 59 | Inside Hose Cabinet | Solid or glass front | The Updated Fire Hazards Analysis contains a detailed listing of Inside Hose Stations. |
| **HYDRANTS AND HOSE HOUSES No. of Units** | **Name** | **Type** | **Description** |
| 9 | Fire Hydrants with Hose Houses | Non-freeze | 150 feet of 2-½" hose self-draining attached with 100 feet of spare hose as well as 150' of spare 1-½" hose in cabinet. Misc. equipment is also contained in the cabinets. |
| 2 | Fire Hydrants | Non-freeze | Located outside the protected area boundary. No hose cabinet or equipment provided. |

Table 9.11-1 - "Fire Extinguishing System Major Component Data" (Continued)

| DELUGE SYSTEMS No. of Units | Name | Type |
|---|---|---|
| 1 | Main Transformer | Fog type water spray |
| 2 | Auxiliary Transformers | Fog type water spray |
| 2 | House Area Transformers | Fog type water spray |
| 1 | Turbine Lube Oil Reservoir | Fog type water spray |
| 1 | Technical Support Center Ventilation Unit | Fog type water spray |
| 1 | Auxiliary Building Stairwell | Fog type water spray |
| 1 | Auxiliary Building Hatchway | Fog type water spray |
| 2 | Control Room Outside Air Filter Units | Fog type water spray |

Halon Systems

The Halon 1301 Systems' extinguishing agent is a gas, Bromotrifluromethane ($CBrF_3$), which is colorless, odorless, electrically non-conductive and acts as an effective medium for controlling and extinguishing most fires by inhibiting the chemical reaction of fuel and oxygen. This is a clean extinguishing agent as it leaves no residue. The Halon 1301 vapor has a low level of toxicity. Based on Underwriters' Laboratories tests, the agent is classified as Group 6, which is the least toxic classification of life hazard for concentrations up to 20%.

The Halon is stored as a pressurized liquid in cylinders. Cylinder sizes vary with the individual systems.

Halon Systems for Safety Related Equipment Areas are Located as Follows:

| | |
|---|---|
| Fire Area 36A | East Switchgear Area |
| Fire Area 36B | West Switchgear Area |
| Fire Area 41 | Cable Spreading Room |
| Fire Area 42 | Control Room Complex Area (walk-in cabinet only) |

The Halon is supplied to each area by a piping/nozzle arrangement. Each storage bottle is protected against over-pressurization by a burst disc.

Carbon Dioxide Suppression System

This system provides total $CO_2$ flooding capabilities for the Turbine Generator Exciter (Fire Area 46), utilizing high pressure $CO_2$ storage tanks as a supply source. The system is activated by two fixed temperature heat detectors located in the Exciter housing. The detectors are cross zoned such that both detectors need to alarm to generate an actuation signal. In addition to operating the releasing solenoid, the control system closes dampers on the Exciter to isolate cooling air inlets and outlets, and operates five alarm indicating lights, one at each door (three outside) and two inside the Exciter.

Wet Pipe Sprinkler System

Sprinkler heads are constructed to open automatically by means of a fusible link whenever the surrounding temperature exceeds a predetermined point. The sprinkler heads are installed either in the pendant position or upright position. These systems are located throughout the plant.

Dry Pipe Sprinkler System

Sprinkler heads are constructed to open automatically by means of a fusible link whenever the surrounding temperature exceeds a predetermined point. When a sprinkler head opens, compressed air trapped in the line escapes and opens the dry pipe valve, supplying water to the open sprinkler head(s). This system is utilized in the diesel generator rooms (Fire Areas 35A, 35B and Warehouse).

Preaction Sprinkler Systems
Room 19 Air Comp Room

Sprinkler heads and spray nozzles are constructed to open automatically by means of a fusible link whenever the surrounding temperature exceeds a predetermined point. Sprinkler heads are installed in the vertical position at the ceiling level. Spray nozzles are installed horizontally and are located at ~10' intervals in each cable tray. The water supply control valve is opened by operation of an independent fire detection system which then allows water to reach the sprinkler heads. This system is utilized in the air compressor room (Fire Area 32).

Turbine Generator

A preaction system is installed for the protection of the Turbine/Generator bearings and the area under the Turbine shroud/lagging (Fire Area 46). The system is supplied from the Turbine Building standpipe loop. For this system, one nozzle and one detector is installed at each bearing location. Both the nozzle and detector are designed to allow easy removal for Turbine/Generator maintenance. Sprinkler heads are installed in the Turbine shroud/lagging compartment and provide area wide coverage. The system has supervisory air to provide indication of an opened spray nozzle or sprinkler head. The supervisory air system uses a dedicated air compressor.

Water Curtains

Water curtains are open head sprinklers actuated by a fusible link valve which opens at a predetermined temperature. Water Curtain Systems are located above the door openings between the Turbine Building and Auxiliary Building to provide additional protection from a fire in the Turbine Building.

### 9.11.4.4 System Operation

The fire detection system functions automatically to provide warning of a fire and may actuate suppression systems as well.

The lead fire pump (normally the motor driven fire pump) can be started as follows:

a) Automatically on low pressure in the water distribution system; or

b) Automatically whenever a transformer spray thermostat calls for the deluge valve to open; or

c) Manually from the control room (the designated fire control center); or

d) Manually at the intake structure.

The second fire pump (normally the diesel driven fire pump) can be started as follows:

a) Automatically if the lead fire pump fails to start within approximately 10 seconds; or

b) Manually from the control room; or

c) Manually at the intake structure; or

d) Automatically if the header pressure drops below a predetermined pressure after the lead pump has started.

The motor driven fire pump can be shut down from the control room or the intake structure while the diesel driven fire pump can be shutdown only from the intake structure; no automatic shutdown is provided.

The transformer and turbine lube oil reservoir deluge spray systems function whenever a heat sensor detects a predetermined temperature. Any one sensor of an individual system will open the deluge valve to allow water to flow to the spray nozzles.

The control room outside air filter unit water spray systems are manually actuated from the AI-106A and AI-106B panels in the control room when high temperature is detected in the carbon adsorber sections. Manual pull stations are also available local to the filter units. Reset pushbuttons are provided to shutoff the water spray systems when the fire is out to minimize the amount of water discharged into the filter housing.

The TSC, Auxiliary Building stairwell and hatchway deluge systems operate when a fire is detected by specific detectors associated with the system.

Water curtains function when the fusible link valve reaches a predetermined temperature. The opening of the valve causes water flow through the open sprinkler heads. Water flow starts the lead fire pump due to a decrease in supply header pressure, which causes the situation to be alarmed in the control room.

The wet pipe sprinkler system functions when any one of the sprinkler heads opens due to temperature. Additional sprinkler heads open as their individual temperature levels are reached. The opening of any sprinkler head causes the situation to be alarmed in the control room due to water flow. The water flow starts the lead fire pump due to a decrease in header pressure.

The dry pipe sprinkler system functions when any one of the sprinkler heads opens due to temperature. The opening of any sprinkler head causes the release of the compressed air trapped in the piping above the dry pipe valve. When the air pressure is sufficiently reduced, water pressure exerted on the bottom side of the valve clapper causes the valve to open and sounds an alarm in the control room due to water flow. The water flow is directed to the open sprinkler head(s) and the lead fire pump starts due to a header pressure decrease. Additional heads open as their individual temperature levels are reached.

The Turbine Generator bearings and the area under the Turbine shroud/lagging is protected by a pre-action system. Under normal conditions, all sprinkler head and spray nozzle piping remains dry and is monitored for leaks by a supervisory air system. If a leak in the piping occurs, the compressed air escapes and an alarm sounds in the control room indicating low system air pressure. The system piping is supplied with water via a pre-action deluge valve that operates when a detector is alarmed. Normally, the detector will alarm and open the pre-action deluge valve. The system piping will then be supplied with water. Water in the system piping remains static until one or more spray nozzles and/or sprinkler heads open. Additional spray nozzles and/or sprinkler heads open as their individual temperature levels are reached.

The Turbine Generator Exciter is protected by a Carbon Dioxide system. This system provides total $CO_2$ flooding capabilities for the Turbine Generator Exciter (Fire Area 46), utilizing high pressure $CO_2$ storage tanks as a supply source. The system is activated by two fixed temperature heat detectors located in the Exciter housing. The detectors are cross zoned such that both detectors need to alarm to generate an actuation signal. In addition to operating the releasing solenoid, the control system closes dampers on the Exciter to isolate the cooling air inlets and outlets, and operates five alarm indicating lights, one at each door (for a total of three) and two located inside.

Fire system piping was initially flushed and filled from the clarifier surge tank by utilizing one or both of the Demineralized Water System's clarifier booster pumps through a connection to the fire main system. The system can be flushed and filled with any suitable clean water source after any system actuation prior to the system being returned to operation.

The Halon system is actuated automatically by either signal(s) from the detection system or from a manual pull station(s). The protected areas are isolated by the closing of ventilation supply and exhaust ducts on receipt of an alarm signal to contain the necessary concentration of Halon, in the protected area, to extinguish the fire.

### 9.11.4.5 Plant Design and Construction Features

The plant has been divided into fire areas for evaluation against 10 CFR 50, Appendix R Section III G, J, and O criteria. Redundant safe shutdown related equipment, components and systems are provided with adequate spatial separation or are separated by fire resistive barriers as described in the Safe Shutdown Analysis. The control room is the designated fire control center. In case of a fire in this area, Abnormal Operating Procedure AOP-6 instructs operators to proceed to the alternate shutdown panels AI-179, AI-185 and AI-212.

Walls enclosing separate fire areas utilize fire resistive construction (OPPD Drawing D-4098). Most configurations are listed in the UL "Fire Resistance Directory." Openings in plant fire barriers are protected as practical, by rated fire doors, fire dampers, and fire barrier penetration seals.

A thorough analysis has been conducted of the separation of functionally redundant cables necessary for safe shutdown as a part of the Appendix R review. This analysis verified that the ability to safely shut down the plant is assured during a fire either by: 1) satisfying the requirements of Appendix R Section III.G and/or L; or 2) a formal exemption submitted to the NRC to justify deviations from the protection prescribed in Appendix R.

Further description of plant design and construction features is contained in Fort Calhoun Station Fire Hazard Analysis and Safe Shutdown Analysis.

### 9.11.5 System Design Evaluation

A systematic approach was utilized for the review of the fire hazards and their exposure to safety-related equipment and components necessary for safe shutdown within each fire area. The type and quantity of combustible materials, the resulting combustible loading in the area, and the fire protection features for the area were identified. The effects of postulated fires on the performance of safe shutdown functions and the minimization of radioactive releases to the environment were evaluated based on available documentation.

A safe shutdown analysis has been performed on an area-by-area basis to satisfy the provisions of 10 CFR 50 Appendix R. NRC evaluation of fire protection for safe shutdown is contained in the following documents:

- Safety Evaluation Report (SER), Fort Calhoun Power Station Unit 1, (August 23, 1978).
- Amendment No. 53 to Facility Operating License No. DPR-40 for the Fort Calhoun Station Unit 1, (November 17, 1980).
- Safety Evaluation Report, Fort Calhoun Nuclear Power Station, 10 CFR 50 Appendix R, Items III.G and III.L., (April 8, 1982). Revisions to the Appendix R SER were issued by the NRC on August 12, 1982; July 3, 1985; November 5, 1985; and July 1, 1986.
- Fort Calhoun Station I & E Inspection Report 83-12, (July 1, 1983).
- Letters to OPPD granting exemptions from 10 CFR 50 Appendix R, (July 3, 1985).
- USNRC Safety Evaluation Report, Issuance of Exemption from the Requirements of 10 CFR Part 50, Appendix R, Fort Calhoun Station, Unit No. 1 (TAC No. M99724), May 21, 1998, OPPD Tracking No. NRC-98-083.

### 9.11.6 Tests and Inspections

Specific measures are established in the QA Plan (see USAR Appendix A, Sections A.11 and A.19) for independent inspection of activities affecting fire protection. This program is executed by, or for, the organization performing the activity to verify conformance with documented modification drawings and test procedures for accomplishing the activities.

The QA Plan (see USAR Appendix A, Sections A.11, A.12 and A.13) assures that testing is performed and verified by inspection and audit to demonstrate conformance with design and system readiness requirements. The tests are performed in accordance with written test procedures. The test results are properly evaluated and appropriate actions taken if required.

The plant fire protection systems are subjected to periodic tests and inspections through performance of Fort Calhoun Station Operating Instructions and surveillance tests. These tests and inspections, and their respective frequencies are generally in accordance with the applicable governing NFPA code and/or the requirements of American Nuclear Insurers. The on-duty Shift Manager reviews and signs the inspection/test procedure following its performance.

The QA Program for fire protection provides for the identification of items that have satisfactorily passed required tests and inspections through surveillance as well as QA inspections and tests covered by Standing Orders and the QA Plan.

Detailed procedures have been developed for testing the fire protection equipment. These procedures specifically identify the groups responsible for the performance of the test and the frequency at which the test is to be performed. The procedures fulfill the objective of maintaining the operability of the fire protection system in accordance with commitments made to the NRC related to fire protection.

Former fire protection technical specifications are a part of Fort Calhoun Station's Fire Protection Program. The periodic testing and inspection requirements as well as the Limiting Conditions for Operation (LCOs) and compensatory actions which were formerly part of the Technical Specifications are presented in Tables 9.11-2 and 9.11-3. Administrative controls will implement the compensatory actions for LCOs and the test and inspection requirements presented in Tables 9.11-2 and 9.11-3.

Table 9.11-2 - "Fire Protection Operability Requirements"

| System | Requirement | Applicability | Condition | Required Action | Time Requirement |
|---|---|---|---|---|---|
| 1. Fire Detectors | Each fire detector zone shall be operable. | Applies to fire detection and fire extinguishing subsystems in nuclear safety related areas. | 1. As a minimum, 50% of the fire detection instrumentation in zones outside containment shall be operable (with no two adjacent detectors in a zone inoperable). | 1. Outside Containment<br>With more than 50% inoperable detector(s) in a zone in safety related areas or with two adjacent detectors in a zone inoperable:<br>a. Establish a fire watch patrol to inspect the zone with the inoperable instrument(s) at least once every hour<br>and<br>b. Restore the inoperable instrument(s) to operable status | a. Within one hour<br>b. Within 14 days |
| | | | 2. In the Containment Building, all but one (1) fire detection zone must be operable, with 50% or more of the detectors in a zone operable, except as provided in 3 below. | 2. Inside Containment<br>a. Establish a fire watch patrol to inspect the zone with more than 50% inoperable instrument(s) at least once per 8 hour operating shift<br>and<br>b. Restore the inoperable instrument(s) to operable status | a. Within one hour<br>b. Within 14 days |
| | | | 3. The provisions set forth in 2 above do not apply to time periods during which Containment Integrated Leak Rate Tests are being performed. | | |

| System | Requirement | Applicability | Condition | Required Action | Time Requirement |
|---|---|---|---|---|---|
| 2. Fire Suppression Water System | Fire suppression water system shall be operable, except during system testing, jockey pump maintenance or training (not to exceed 7 consecutive days) with both fire pumps, each with a minimum capacity of 1800 gpm, with their discharge aligned to the fire suppression header and automatic initiation logic for each fire pump. | Applies to fire extinguishing subsystems and their associated fire detection systems required for proper operation in nuclear safety related areas. | 1. With less than the required equipment<br><br>2. With no fire suppression water system operable | 1. Restore the inoperable equipment to operable status<br><br>2.a. Establish a backup fire suppression water system<br><br>2.b. If (a.) above cannot be fulfilled:<br><br>1) place the Reactor in Hot Standby<br><br>AND<br><br>2) place the Reactor in Cold Shutdown | 1. Within 7 days<br><br>2.a. Within 24 hours<br><br>2.b.<br><br>1) Within the next 6 hours<br><br>2) Within the following 30 hours |
| 3. Sprinkler System in the Diesel Generator Rooms, the sprinklers above the steam driven auxiliary feedwater pump, the sprinkler/spray nozzle system in the compressor room, and the deluge system in the personnel corridor between fire areas 6 and 20 (on the 989'-0" elevation protecting stairway A-971-1) | Shall be operable except during system testing. | Applies to fire extinguishing subsystems and their associated fire detection systems required for proper operation in nuclear safety related areas. | Any system inoperable | 1.a. Areas in which redundant systems or components could be damaged:<br><br>Establish a continuous fire watch with backup fire extinguishing equipment.<br><br>b. All other areas:<br><br>Establish an hourly fire watch patrol.<br><br>2. Restore the system to operable status | 1.a. Within one hour<br><br>b. Within one hour<br><br>2. Within 14 days |

| System | Requirement | Applicability | Condition | Required Action | Time Requirement |
|---|---|---|---|---|---|
| 4. Fire Hose Stations | The fire hose stations shall be operable. | Applies to fire extinguishing subsystems in nuclear safety related areas. | One or more stations inoperable | 1. If the inoperable station is the primary means of fire suppression, provide a hose of equivalent capacity which can service the unprotected areas from an operable hose station.<br>2. If the inoperable station is not the primary means of fire suppression, route an additional hose of equivalent capacity which can service the unprotected areas from an operable hose station. | 1. Within one hour<br>2. Within 24 hours |
| 5. Fire Barriers | All fire barriers protecting safety-related areas shall be functional (intact). | Applies to fire barriers in nuclear safety related areas. | One or more fire barrier nonfunctional | 1. Establish a continuous fire watch on at least one side of the affected barrier<br>OR<br>Verify the operability of the fire detectors on at least one side of the barrier and establish an hourly fire watch patrol.<br>2. Restore to functional status | 1. Within one hour<br>2. Within 7 days |
| 6. Halon Systems (Control Room, Switchgear Room, and Cable Spreading Room) | Shall be operable with the storage tanks having at least 90% of full charge pressure and 95% of full charge weight or level. | Applies to fire extinguishing subsystems and their associated fire detection systems required for proper operation in nuclear safety related areas. | Halon System inoperable | 1. Establish a continuous fire watch with backup fire suppression equipment<br>2. Restore the system to operable status | 1. Within one hour<br>2. Within 14 days |

| Basis |
| --- |
| The fire protection system provides a means for detecting, alarming, and extinguishing plant fires. The system is divided into the fire detection subsystem and the fire extinguishing subsystem.<br><br>The fire detection subsystem is an instrumentation system which alarms control room operators of a fire, indicating fire location on a panel in the control room and providing a local indication from the detector in the affected zone.<br><br>The fire extinguishing subsystem includes the sprinklers which protect the Diesel Generator Rooms. Also included are the hose stations which protect the immediate vicinity outside the entire plant, hose cabinets inside the intake structure, and other miscellaneous equipment.<br><br>Requirement 2 above allows one of the four fire detection zones to be inoperable in the containment. One inoperable zone would not significantly reduce fire detection capability or margin of safety or protection for the following reasons:<br><br>(1) A large number of fire detectors at many locations and elevations exist in the containment vessel.<br><br>(2) During normal operation, containment fans provide complete circulation and mixing of containment air, thereby exposing most of the containment fire detectors to any locally produced combustion products.<br><br>(3) Normally, containment ventilation duct fire detectors are operable and are continuously exposed to air streams originating from all locations in the containment.<br><br>The functional integrity of the fire barrier penetrations ensures that fires will be confined or adequately retarded from spreading to adjacent portions of the facility. This design feature minimizes the possibility of a single fire rapidly involving several areas of the facility prior to detection and extinguishment. The fire barrier penetrations are a passive element in the facility fire protection program and are subject to periodic inspections.<br><br>Fire barriers, including cable penetration barriers, penetration seals, fire doors and dampers are considered functional when the visually observed condition is the same as the as-designed condition. For those fire barriers that are not in the as-designed condition, an evaluation shall be performed to show that the modification has not degraded the fire rating of the fire barrier penetration.<br><br>During periods of time when a barrier is not functional, either (1) a continuous fire watch is required to be maintained in the vicinity of the affected barrier, or (2) the fire detectors on at least one side of the affected barrier must be verified operable and an hourly fire patrol established, until the barrier is restored to functional status. |

| Former Technical Specification Interpretation | |
|---|---|
| Interpretation: | Bases: |
| The compensatory measures and reporting requirements provided in Item 1, a and b, above, apply only to those fire detection zones that are located, in whole or in part, in areas where Safety-Related equipment is located.<br><br>The Action Statements of Item 1 do <u>not</u> apply to Fire Detection Zones 14, 15, 16, or 34. Detection Zones 14, 15, and 16 are nonsafety related zones and Detection Zone 34, "Plant Sprinkler Flow," does not contain fire detection instrumentation. | This is consistent with the remainder of the fire protection Former Technical Specification, which only address fire protection components that protect Safety-Related equipment (sprinkler systems and hose stations in the Turbine Building are not addressed). Inoperability of a fire detection zone in the Turbine Building will not jeopardize the capability of the plant to safely shut down in the event of a fire, just as an inoperable fire detection zone in the CARP Building or the TSC, also adjacent to the Safety-Related Auxiliary Building but not addressed in Former Tech Specs, will not.<br><br>The Fire Hazards Analysis includes the Turbine Building detection zones in a summary of plant fire detection and assigns Fire Area 46 to the Turbine Building, but states: "Since this fire area does not affect any of the safety-related features of the plant, no evaluation has been performed in this area." This provides further substantiation for the proposed Former Technical Specification interpretation that would not apply the compensatory measures and reporting requirements specified in the Former Technical Specification to the fire detection zones that are located entirely in non-safety-related areas. |
| During jockey pump maintenance, system testing or training, it is not required that the plant enter Fire Suppression Water System Required Action 1 unless these activities extend past seven consecutive days. Any other impairment to the fire suppression equipment mentioned or implied in the Fire Suppression Water System Section must--as a minimum--be cause for the plant to enter Fire Suppression Water System Required Action 1.<br><br>During jockey pump maintenance, system testing or training, the plant is not required to enter Fire Suppression Water System Required Actions 2.a and 2.b unless impairments to the fire suppression equipment mentioned or implied in the Fire Suppression Water System section constitute a condition where the plant cannot start a fire pump by one of its normally designed available starting methods, with a pump discharge capability of at least 1800 gpm, and cannot align that pump's discharge directly into the plant fire suppression header (plant exterior fire main) through its normally designed available flow path. | Bases for these interpretations are contained in the Former Technical Specifications and the Updated Safety Analysis report. The interpretations are consistent with the definition of operability contained in the Technical Specifications "Definitions" section, and consistent with the analysis contained in the USAR that describe the various methods available to start fire pumps and describe the clean water filling and flushing process which is to be performed prior to placing fire protection systems in operation. |

## Table 9.11-3 - "Fire Protection Surveillance Requirements"

| Fire Protection Features | |
|---|---|
| 1. Fire Detectors | Each fire detector in nuclear safety related areas shall be demonstrated operable:<br><br>a. At least once per 12 months by performance of a channel functional test and a test of the supervision circuitry.<br><br>b. Testing interval for fire detectors which are inaccessible due to high radiation or require an equipment alignment not used in power operation may be extended until such time as the detectors become accessible for a minimum of 36 hours. However, the shutdown need not be extended solely for the purpose of this testing. Such detectors shall be functionally tested at a maximum interval of once per refueling cycle. |
| 2. Fire Suppression Water System | The fire suppression water system shall be demonstrated operable:<br><br>a. At least once per month by starting each pump and operating it for at least 15 minutes.<br><br>b. At least once per month by verifying that each valve in the flow path is in its correct position.<br><br>c. At least once per 12 months by cycling each testable valve (those which can be cycled without endangering the safety of equipment) in the flow path through at least one complete cycle of full travel.<br><br>d. At least once per 18 months by performing a system functional test which includes:<br><br>1. Verifying that each pump develops at least 1800 gpm at a system head of 280 feet.<br><br>2. Cycling each valve in the flow path that is not testable during plant operation through at least one complete cycle of full travel, and<br><br>3. Verify that each fire pump starts automatically on low fire system pressure to maintain the fire suppression water system pressure $\geq$ 100 psig.<br><br>e. At least once per 3 years by performing a flow test of the system in accordance with Chapter 5, Section 11 of the Fire Protection Handbook, 14th Edition, published by the National Fire Protection Association using a clean water source.<br><br>f. At least once per year by visually inspecting the strainer on the discharge side of the fire pumps to verify operability. |

| Fire Protection Features | |
|---|---|
| 3. Sprinkler System in the Diesel Generator Rooms, the sprinklers above the steam driven auxiliary feedwater pump, the sprinkler/spray nozzle system in the compressor room, and the deluge system in the personnel corridor between fire areas 6 and 20 (on the 989'-0" elevation protecting stairway A-971-1) | These systems shall be demonstrated to be operable:<br><br>a. At least once per 18 months:<br><br>1. By visual inspection of the spray/sprinkler headers to verify their integrity.<br><br>2. By visual inspection of each spray/sprinkler nozzle to verify no blockage and no obstruction of the spray area.<br><br>3. By performing a system functional test which includes simulated automatic actuation of the system and verifies that all automatic valves actuate to their correct position.<br><br>b. At least once per 3 years by performing an air flow test through each open head spray/sprinkler header and verifying each open head spray/sprinkler nozzle is unobstructed. |
| 4. Fire Hose Stations | Each fire hose station in nuclear safety related areas shall be verified to be operable:<br><br>a. At least once per month by visual inspection of the station to assure all equipment is available and the system pressure (as determined at the jockey pump pressure gauge) is within limits.<br><br>b. At least once per 18 months by removing the hose for inspection and reracking and replacing any degraded gaskets in the couplings.<br><br>c. At least once per 3 years by:<br><br>1. Partially opening the hose station valves to verify valve operability and no blockage.<br><br>2. Conducting a hose hydrostatic test in accordance with NFPA requirements. |
| 5. Fire Barriers | Fire barriers shall be verified to be functional (intact):<br><br>a. At least once per 18 months by a visual inspection.<br><br>b. Prior to declaring a fire penetration seal functional following repairs or maintenance by performing a visual inspection of the affected penetration. |

| Fire Protection Features | |
|---|---|
| 6. Diesel Fire Pump | The diesel fire pump shall be demonstrated operable:<br><br>a. At least once per month by verifying that the fuel storage tank contains at least 200 gallons of fuel.<br><br>b. At least once per quarter by verifying that a sample of diesel fuel from the fuel storage tank, obtained in accordance with ASTM-D270-65, is within the acceptable limits specified in Table 1 of ASTM-D975-74 with respect to viscosity, water content, and sediment.<br><br>c. At least once per 18 months, by subjecting the diesel to an inspection in accordance with procedures prepared in conjunction with its manufacturer's recommendations for the class of service. |
| 7. Fire Pump Diesel Battery Bank and Charger | The fire pump diesel starting 24-volt battery bank and charger shall be demonstrated operable:<br><br>a. At least once per month by verifying that the electrolyte level of each battery is above the plates.<br><br>b. At least once per quarter by verifying that the specific gravity is appropriate for the continued service of the battery.<br><br>c. At least once per 18 months by verifying that:<br><br>1. The batteries and battery racks show no visual indication of physical damage or abnormal deterioration.<br><br>2. The battery-to-battery and terminal connections are clean, tight, essentially free of corrosion and suitable corrosion protection is used. |
| 8. Halon Systems (Control Room, Switchgear Room, and Cable Spreading Room) | The control room, switchgear room, and cable spreading room halon systems shall be demonstrated to be operable:<br><br>a. At least once per month by verifying that each valve in the flow path is in its correct position.<br><br>b. At least once every 6 months by verifying each halon storage tank pressure and weight or level.<br><br>c. At least once every 18 months by:<br><br>1. Verifying the system, including associated ventilation dampers (if applicable), is actuated by a simulated test signal. Manual and automatic test signals will be alternated every 18 months.<br><br>2. Visual inspection of spray headers to verify integrity.<br><br>3. Visual inspection of all nozzles to ensure no blockage.<br><br>d. At least once every three years by performing an air flow test through each header and nozzle to assure no blockage. |

| Fire Protection Features | |
|---|---|
| 9. Battery Powered Smoke Detectors | Battery powered smoke detectors in nuclear safety related areas shall be demonstrated operable by performance of an operational test performed using a built-in test device at least semi-annually. |

| Basis |
|---|
| The fire protection system provides a means for detecting, alarming, and extinguishing plant fires. The system is divided into the fire detection subsystem and fire extinguishing subsystem.<br><br>The fire detection subsystem is an instrumentation system which alarms control room operators of a fire, indicating fire location on a panel in the control room, and providing local indication from the detector in the affected zone.<br><br>The fire extinguishing system includes the sprinklers which protect the Diesel Generator Rooms. Also included are the hose stations which protect the immediate vicinity outside the entire plant, hose cabinets inside the intake structure, and other miscellaneous equipment.<br><br>Maintaining the operability of the fire protection system under various operating conditions is essential to insure the integrity of various nuclear safety-related plant systems and equipment. The above measures aid in accomplishing this objective.<br><br>Requirement 2.f above provides a program that insures that silt and other material in the river water will not prevent the delivery of water to areas protected by fire water suppression systems. |

Table 9.11-4 - "Fire Hose Station Locations"

| | No. | Location | Elevation | Size |
|---|---|---|---|---|
| 1. | FP-4N | Intake Structure | 1012'-6" | 1.5"/2.5" |
| 2. | FP-4P | Intake Structure | 1012'-6" | 1.5"/2.5" |
| 3. | FP-3C | Yard Area | At grade level | 2.5" |
| 4. | FP-3B | Yard Area | At grade level | 2.5" |
| 5. | FP-3A | Yard Area | At grade level | 2.5" |
| 6. | FP-3F | Yard Area | At grade level | 2.5" |
| 7. | FP-3E | Yard Area | At grade level | 2.5" |
| 8. | FP-3D | Yard Area | At grade level | 2.5" |
| 9. | FP-7A | Auxiliary Building | 989'-0" | 1.5"/2.5" |
| 10. | FP-7B | Auxiliary Building | 989'-0" | 1.5"/2.5" |
| 11. | FP-7C | Auxiliary Building | 989'-0" | 1.5"/2.5" |
| 12. | FP-7D | Auxiliary Building | 989'-0" | 1.5"/2.5" |
| 13. | FP-7E | Auxiliary Building | 989'-0" | 1.5"/2.5" |
| 14. | FP-7F | Auxiliary Building | 989'-0" | 1.5"/2.5" |
| 15. | FP-7G | Auxiliary Building | 989'-0" | 1.5"/2.5" |
| 16. | FP-8A | Auxiliary Building | 1011'-0" | 1.5"/2.5" |
| 17. | FP-8B | Auxiliary Building | 1011'-0" | 1.5"/2.5" |
| 18. | FP-8C | Auxiliary Building | 1011'-0" | 1.5"/2.5" |
| 19. | FP-8D | Auxiliary Building | 1007'-6" | 1.5"/2.5" |
| 20. | FP-8E | Auxiliary Building | 1007'-6" | 1.5"/2.5" |
| 21. | FP-8F | Auxiliary Building | 1007'-6" | 1.5"/2.5" |
| 22. | FP-8G | Auxiliary Building | 1007'-6" | 1.5"/2.5" |
| 23. | FP-8H | Auxiliary Building | 1007'-6" | 1.5"/2.5" |
| 24. | FP-9A | Auxiliary Building | 1025'-0" | 1.5"/2.5" |
| 25. | FP-9B | Auxiliary Building | 1025'-0" | 1.5"/2.5" |
| 26. | FP-9C | Auxiliary Building | 1025'-0" | 1.5"/2.5" |
| 27. | FP-9D | Auxiliary Building | 1025'-0" | 1.5"/2.5" |
| 28. | FP-10A | Auxiliary Building | 1036'-0" | 1.5"/2.5" |
| 29. | FP-10B | Auxiliary Building | 1036'-0" | 1.5"/2.5" |
| 30. | FP-10C | Auxiliary Building | 1036'-0" | 1.5"/2.5" |
| 31. | FP-10D | Auxiliary Building | 1036'-0" | 1.5"/2.5" |
| 32. | FP-10E | Auxiliary Building | 1036'-0" | 1.5"/2.5" |

### 9.11.7 General References

9.11.7.1 Safety Evaluation by the Office of Nuclear Reactor Regulation supporting Amendment No. 38, 2/14/78.

9.11.7.2 Safety Evaluation by the Office of Nuclear Reactor Regulation supporting Amendment No. 40, 8/23/78.

9.11.7.3 Safety Evaluation by the Office of Nuclear Reactor Regulation supporting Amendment No. 53, 11/17/80.

9.11.7.4 Safety Evaluation Report, 10 CFR 50, Appendix R, Items III.G and III.L, 4/8/82.

9.11.7.5 Safety Evaluation Report Revision, 10 CFR 50, Appendix R, Items III.G and III.L, 8/12/82.

9.11.7.6 Safety Evaluation by the Office of Nuclear Reactor Regulation related to exemptions from 10 CFR 50, Appendix R, 7/3/85.

9.11.7.7 Safety Evaluation by the Office of Nuclear Reactor Regulation (Alternate Shutdown Capability), 11/5/85.

9.11.7.8 Safety Evaluation by the Office of Nuclear Reactor Regulation related to Appendix R, 10 CFR 50, Fire Protection Modifications, 7/1/86.

9.11.7.9 Generic Letter 81-12, Fire Protection Rule (45FR76602, Nov. 19, 1980), 2/20/81.

9.11.7.10 Generic Letter 85-01, Fire Protection Policy Steering Committee Report, 1/9/85.

9.11.7.11 Generic Letter 86-10, Implementation of Fire Protection Requirements, 4/24/86.

9.11.7.12 Generic Letter 88-12, Removal of Fire Protection Requirements from Technical Specifications, 8/2/88.

9.11.7.13 IE Bulletin 75-04A, Cable Fire at Browns Ferry Nuclear Plant, 4/3/75.

9.11.7.14 IE Bulletin 75-04B, Cable Fire at Browns Ferry Nuclear Plant, 11/3/75.

# 9.12 COMPRESSED AIR SYSTEM

## 9.12.1 Design Bases

The compressed air system provides compressed air to the instrument air and the service air headers.

The instrument air header provides air for pneumatic controls and the actuation of valves, dampers, and similar devices, as well as the fuel handling machine in the containment. The service air system provides air for portable maintenance tools (such as stud tensioners and chipping hammers), large valves, and the air operated hoist in the intake structure.

The system has the following design bases:

a. Instrument and service air regulation between 80 and 100 psig;

b. Maximum instrument air dew point of -20°F;

c. Quantity of instrument air sufficient to provide for all pneumatic controls and valve and damper operators expected to operate under normal and post accident operating conditions;

d. Quantity of service air sufficient for all equipment expected to operate simultaneously plus an allowance for the use of maintenance tools;

e. Failure of the service air distribution system not to cause the loss of instrument air.

System operation is not required to initiate operation of engineered safeguards equipment since all air operated valves and dampers required to control the accident were designed to assume the accident-controlling position on loss of air pressure or are provided with safety grade passive accumulators or nitrogen backup systems. Containment penetrations for the hydrogen purge system and hydrogen analyzer VA-81B have fail-open, air-operated valves which receive an auto-close signal on CIAS, but these valves do not have backup accumulators. Acceptability of this design is discussed in Section 5.9.5. Further, air is not required for the reactor protective system.

Those portions of the instrument air system that are required to operate engineered safety features or essential auxiliary support systems valves, e.g., from the check valves downstream through the accumulators, tubing and components, are part of the plant's engineered safeguards, as defined in Section 6. The instrument air system is designed in accordance with the requirements of Appendix N. See P&IDs 11405-M-264. For more supporting detail of components, the Technical Specifications, the CQE Manual, the EEQ Manual, and the Regulatory Guide 1.97 Responses should be consulted.

### 9.12.2 System Description

The compressed air system is shown in P&ID 11405-M-263. The major components of this system are located in the basement of the auxiliary building on the east side.

Air is supplied by three identical two stage compressors which operate automatically to maintain air pressure. The compressors are connected to a discharge manifold which feeds the instrument and service air systems.

Instrument air flows first through an air receiver which holds a reserve supply of air. From the receiver it flows through a prefilter, an air dryer, an afterfilter, and then to the distribution system.

A side stream dewpoint analyzer continuously monitors the dewpoint of the instrument air supply downstream of the air dryers.

The service air also flows first to a receiver. If the pressure in the instrument air system drops below a set level, a pressure control valve down stream of the receiver closes, shutting off flow to the service air system.

### 9.12.3 System Components

The air compressors are two stage, intercooled and aftercooled, heavy duty type with non-lubricated cylinders. The unit capacity is 710 SCFM oil-free, dry air at 125 psig. The intercoolers, aftercoolers and cylinder jackets are cooled by the turbine plant cooling water system.

The receivers are vertical steel tanks designed and fabricated in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code.

The normal service and standby air dryers are of the desiccant non-heat, regenerated dual tower unit. One tower is in service while the other is regenerated.

Piping is in accordance with USAS B31.1. Instrument air piping is mostly copper. (Reference: Technical Services Analysis Request 87-04)

## 9.12.4 System Operation

The air supply system operates automatically. When air demand is low, one compressor operates. If the air pressure continues to drop, a second compressor starts. The third compressor is kept on standby and can be operated manually if necessary. The normal instrument air dryer operates and regenerates automatically. The standby dryer also operates and regenerates automatically. The standby dryer is manually placed in service whenever the normal service air dryer is unavailable.

If the instrument air dew point is greater than or equal to -20°F or if there is an indication of high air moisture, instructions are provided to operators for specific actions to correct the situation.

## 9.12.5 Design Evaluation

The system provides sufficient instrument and service air to satisfy all pneumatic instruments, controls, valves, dampers and other equipment. The compressor capacity provided is in excess of the design maximum demand. Loss of the system would not prevent placing the plant in a shutdown condition from normal plant operation or any accident situation since the instrument air system is not required for a safe plant shutdown.

All air operated valves which are required to operate during loss of instrument air do so by spring actuation following removal of air pressure from their operators, or have air storage tanks (accumulators). The removal of air pressure is actuated by solenoid valves.

Following the trip, decay heat can be removed from the plant through safety valves on the main steam lines. These valves depend only on springs for actuation. The steam removed from the steam generators through the safety valves can be replaced using the motor driven auxiliary feedwater pump.

The instrument air system is also not required for any of the engineered safety features to operate properly. Air operated valves fail upon loss of air pressure in a position for the engineered safeguards to function properly, or have accumulators to keep safety related components operable for a required time. Containment penetrations for the hydrogen purge system and hydrogen analyzer VA-81B have fail-open, air-operated valves which receive an auto-close signal on CIAS, but these valves do not have backup accumulators. Acceptability of this design is discussed in Section 5.9.5. The twelve safety injection valves inside the containment which must be operated after the accident to adjust the flow are electric motor operated.

The functional requirements for safety related components that have accumulators have been established, and functional testing has verified the operability of these components. To make these components independent of the instrument air system during a Design Basis Accident, each is equipped with an air storage tank (accumulator) which is pressurized during normal operations. If the pressure in the instrument air system drops, a check valve in the line to the air storage tank closes, which isolates the tank from the system and provides a supply of air to the component for the required time period. Valves HCV-344, HCV-345, LCV-383-1, LCV-383-2, HCV-400A/B/D, HCV-401A/B/D, HCV-402A/B/D, HCV-403A/B/D, HCV-480, HCV-481, HCV-484, HCV-485, HCV-438B and HCV-438D do not depend on an air storage tank (accumulator) upon loss of Instrument Air; dedicated $N_2$ cylinders are interfaced to these valves. Table 9.12-1 includes the time requirements for accumulator operability, and valve operability requirements following a design basis event.

### 9.12.6 Availability and Reliability

The system was designed for a high standard of reliability. Since some of the loads on the system are of an occasional nature (e.g., waste disposal demineralizer service and maintenance tool operations) the system operates at a very low load factor. One air compressor is a spare; operation of one of the others is normally sufficient. Bypasses are provided so that either of the air receivers can be taken out of service. The standby air dryer provides full capacity backup to the normal service air dryer. In the unlikely event neither air dryer is available both air dryers can be bypassed. Segments of both air supply systems can be isolated for maintenance or repair without shutting down the entire system.

### 9.12.7 Tests and Inspection

The air receivers were hydrostatically tested in the shop. Other components were tested during the functional tests prior to plant operation. The system was tested with regard to flow paths, capacity and mechanical operability. The compressors and valves were tested for actuation at the design setpoints. Pressure and temperature indicating and controlling instruments were calibrated and checked for operability.

The equipment is accessible for inspection and maintenance at all times.

Table 9.12-1 - "Safety Related Valves and Bubblers Operable after Loss of Instrument Air"

| Valve Tag | System | Location Of Valve | Length of Time Valve Remains Operable (Hrs) (Note 1) | Fail Safe Position |
|---|---|---|---|---|
| HCV-238 | CVCS | CONT | 25.0 | OPEN |
| HCV-239 | CVCS | CONT | 25.0 | OPEN |
| HCV-240 | CVCS | CONT | 25.0 | CLOSED |
| HCV-304 | HPSI | RM 21 | -- | OPEN |
| HCV-305 | HPSI | RM 21 | -- | OPEN |
| HCV-306 | HPSI | RM 13 | -- | OPEN |
| HCV-307 | HPSI | RM 13 | -- | OPEN |
| HCV-385 | SI&CS | CORR 4 | 13.0 | OPEN |
| HCV-386 | SI&CS | CORR 4 | 13.0 | OPEN |
| HCV-400A/B/D | CCW | RM 69 | -- | NOTE 3 |
| HCV-401A/B/D | CCW | RM 69 | -- | NOTE 3 |
| HCV-402A/B/D | CCW | RM 69 | -- | NOTE 3 |
| HCV-403A/B/D | CCW | RM 69 | -- | NOTE 3 |
| HCV-438B/D | CCW | RM 13 | $N_2$ B/U | OPEN |
| HCV-480 | CCW | CORR 4 | 24.0 (NOTE 4) | OPEN |
| HCV-481 | CCW | CORR 4 | 24.0 (NOTE 4) | OPEN |
| HCV-484 | CCW | CORR 4 | 24.0 (NOTE 4) | OPEN |
| HCV-485 | CCW | CORR 4 | 24.0 (NOTE 4) | OPEN |
| HCV-2987 | SI | RM 13 | 24.0 | NOTE 3 |
| LCV-383-1 | SI | RM 21 | $N_2$ B/U | OPEN |
| CV-383-2 | SI | RM 21 | $N_2$ B/U | OPEN |
| YCV-1045A/B | MS | RM 81 | 0.5 | OPEN |
| YCV-1045 | MS | RM 19 | 3(NOTE 5) | OPEN |
| A,B,C,D/FIC-383 | SI&CS | RM 25A | 12.0 | -- |
| PCV-6680A-1 | VA | RM 81 | 8 (NOTE 2) | OPEN |
| PCV-6680A-2 | VA | RM 81 | 8 (NOTE 2) | OPEN |
| PCV-6680B-1 | VA | RM 81 | 8 (NOTE 2) | OPEN |
| PCV-6680B-2 | VA | RM 81 | 8 (NOTE 2) | OPEN |
| PCV-6682 | VA | CR | 8 (NOTE 2) | OPEN |
| HCV-1107A | AFW | CONT | 8 | OPEN |
| HCV-1107B | AFW | RM 81 | 8 | OPEN |
| HCV-1108A | AFW | CONT | 8 | OPEN |
| HCV-1108B | AFW | RM 81 | 8 | OPEN |
| FCV-1368 | AFW | RM 19 | 8 | OPEN |
| FCV-1369 | AFW | RM 19 | 8 | OPEN |
| HCV-2898A | CCW | RM 81 | 8 | CLOSED |
| HCV-2898B | CCW | RM 81 | 8 | CLOSED |
| HCV-2899A | CCW | RM 81 | 8 | CLOSED |
| HCV-2899B | CCW | RM 81 | 8 | CLOSED |

Table 9.12-1 - (Continued)

**NOTES:**

1. According to OSAR 87-10 unless otherwise noted

2. Per MR-FC-87-20

3. These valves fail open on a loss of DC control power to their air solenoids, and fail as-is on a loss of instrument air.

4. These valves are equipped with backup nitrogen accumulators to keep them closed during the injection phase (i.e., pre-RAS period) of a large break LOCA in spite of a loss of instrument air pressure. The duration listed is bounding for the pre-RAS period of a large break LOCA.

5. Installed Per MR-FC-98-008 (DCN 2832)

## 9.12.8 General References

9.12.8.1 Operations Support Analysis (OSAR) 87-10, Determine Which Valves with Air Accumulators are Required for Safe Shutdown, April 6, 1988.

9.12.8.2 Letter LIC-89-0098, Response to NRC Generic Letter 88-14, Instrument Air Supply System Problems Affecting Safety Related Equipment, February 21, 1989.